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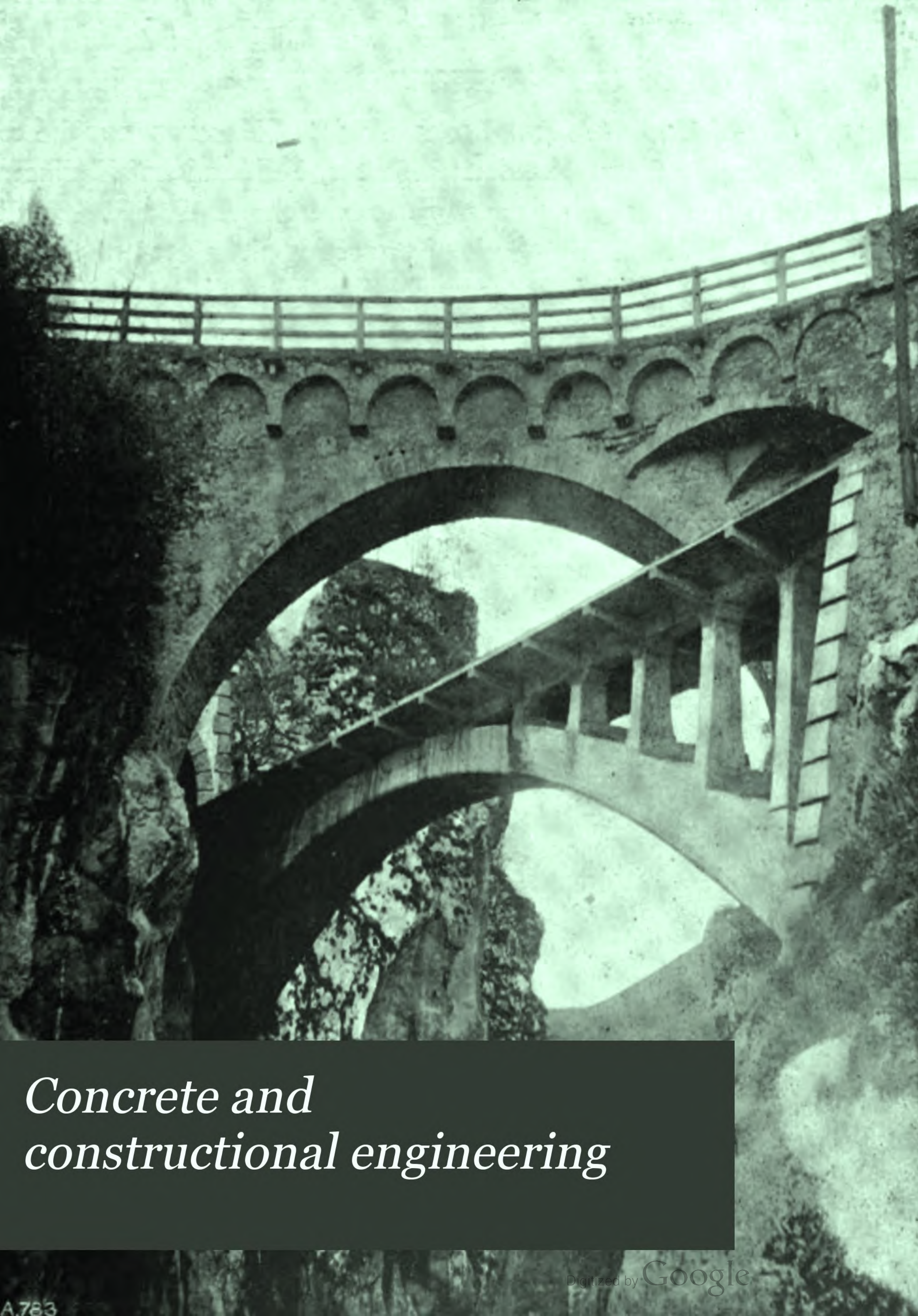

Concrete and constructional engineering

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A Bi-Monthly Journal for Engineers, Architects and Surveyors—Contractors and Builders—and all Workers in Cement, Concrete, Reinforced Concrete, and Constructional Steel.

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CONCRETE AND CONSTRUCTIONAL ENGINEERING

Volume III. No. 1. MARCH, 1908.

EDITORIAL NOTES.

THE CONCRETE INSTITUTE.

In our preceding issue we indicated the possible formation of an institute devoted particularly to concrete and reinforced concrete. It is with great pleasure that we are able to announce that The Concrete Institute has now been formed, with a nucleus of one hundred founders, and although the official particulars as to constitution, officers, etc., are still in the confidential stage, we do not think we shall be indiscreet in stating that to our knowledge the Institute is eminently representative of the professions and industries concerned, and that it will have a Council that should do credit to the subject. A most interesting feature we believe is that an important proportion of the founders are members of the Institution of Civil Engineers, and hold public appointments.

We understand the idea of the formation of this Institute has been appreciated by almost all who have heard of it, and there seems to be a general opinion that just as the iron and steel interests have a long recognised centre in the Iron and Steel Institute, it is high time that those interested in questions of practice, research, and legislation affecting the use of concrete and reinforced concrete should have the Concrete Institute as their centre.

There is certainly ample work for the new Institute in research alone, whilst some of the legislative anomalies that effect concrete and reinforced concrete, both directly and indirectly, require its speedy attention. The professional man, the public official, the building owner, the general contractor and specialist, and even the ratepayer suffer at the moment from certain defects in our legislation on matters appertaining to concrete. Similarly the designer and specialist alike suffer from a lack of technical and scientific information, without which it is difficult to use concrete and reinforced concrete as practicably, economically, and systematically as both would wish.

CO-OPERATION OF THE TECHNICAL INTERESTS.

Much appertaining to the present state of our enactments and regulations, and much appertaining to certain flaws in our technical knowledge, has been due to a certain absence of co-operation between the professional and official elements on the one hand, and the contractors and specialists on the other. A centre for the discussion of questions of mutual importance, such as has long been found for matters appertaining to iron and steel in the Iron and Steel Institute, has been lacking. The Concrete Institute should fill this gap.

It is pleasing to hear that many of the leading specialists in concrete and reinforced concrete, and several of the great contractors, have intimated their intention of actively assisting the work of the Institute if called upon, and these important industrial interests should be adequately represented on the Council by some men of practical experience and industrial standing.

All questions of trade or wages, as in the case of the Iron and Steel Institute, will be naturally tabooed, but there are so many matters in which the work of the public official and his professional colleague in private practice could be facilitated, if he was in closer touch with the difficulties the contractor and specialist have to contend with. The possibility of the various elements concerned now meeting should do much to lead to a better understanding.

In shipbuilding, where Great Britain shines, such co-operation has borne remarkable fruit, and the work of the Institution of Naval Architects in this direction has been second to none. If in time the Concrete Institute in any way approaches in utility the work of that historical institution it will indeed be something for the building owner to be thankful for.

LOCAL GOVERNMENT BOARD LOANS AND REINFORCED CONCRETE.

The amount of correspondence that continues to reach us as to the attitude of the Local Government Board in differentiating in its loan periods so adversely against reinforced concrete, indicates the wide area over which this hardship is being felt by local authorities. Our contributors, no matter what their particular sphere of work may be, are also calling attention to the subject in their various articles for this journal.

We have it on the best authority that the association which represents the interests of the technical officials of our local authorities is also having the matter brought so frequently to its notice that it has had to call a special committee of members and others to consult on the matter, with a view, we believe, of specifying the nature of the grievance.

We were recently even reminded that it is this one public department which has no actual practical experience of reinforced concrete that is hampering the work of the local authorities, while the actual spending departments of the Government, such as H.M. Office of Works, the Admiralty, and the War Office, are using reinforced concrete.

In this issue the matter is frequently referred to under various headings, and we do not wish to labour the question in this column, but, as before indicated, we emphatically claim that reinforced concrete should be placed on the same footing as other building materials, subject to due precautions and rules, and subject to such tests as the Local Government Board may think fit. To allow a loan period of 30 years on timber roof trusses in one building and to only allow 15 years on reinforced concrete trusses in another is almost more ridiculous than the granting of 30 years on a cast-iron main, whilst limiting the loan period to 15 years on a reinforced concrete one.

There can, of course, be no doubt that care is required in reinforced concrete, and that the Local Government Board must preserve the interests of the ratepayer against poor building construction, but the powers of the Local Government Board to examine plans, to frame conditions for tests, etc., are sufficiently wide to protect the ratepayer, without interfering with the wish of his technical officials to economise in the same way as the Government officials of our great spending departments are saving the taxpayers' money on post offices and other Government works.

It is regrettable that we should have to constantly refer to the subject, but we think it our duty, both in the interests of the members of the technical professions and the industries concerned; and we sincerely trust that the position as it now exists may be shortly modified. One sentimental fact, too, is particularly annoying, apart from all other practical considerations, namely, this burlesque of departmental mikadoism is calling upon us the contempt of the none too benevolent foreigner.

BUILDING BYELAWS.

We give the first place to the question of loans, but we are afraid we shall soon also have to take up the matter of local byelaws, as far as they militate against the use of reinforced concrete, and here, again, it is the Local Government Board which will have to be called upon to meet modern conditions, and amend both its so-called "model" clauses, and the principles upon which it settles such local clauses as may be put before them for consideration. But whilst the byelaws which are controlled or influenced by the Local Government Board are no doubt important, we should not forget that the Building Act relating to this Metropolis, and several Building Acts governing other large centres of building operations require amendment. Two important municipalities, we understand, have already Bills in Parliament which will probably lead to modification in the present antiquated rules on the subject. Others, we trust, will follow suit for the Parliamentary Session of next year.

THE GROUTING MACHINE AND PORTLAND CEMENT.

A paper of the highest technical importance to all interested in the preservation of ancient buildings was read before the Royal Institute of British Architects last month by Mr. Francis Fox, M.Inst.C.E., when he described the possibilities of the grouting machine, and presented some valuable drawings showing its application.

There can be no doubt that the usefulness of the grouting machine has not yet been realised by the architectural professions, and thus Mr. Fox's paper before the Institute should have practical results. The grouting machine is, however, no doubt so well known to the majority of our readers among the engineering professions, that we do not propose to deal with it technically in these columns.

One point we should like to refer to, and that is the importance of the Portland cement used in grouting being of the highest possible quality, and of very fine grinding. We were pleased to observe in this connection that Mr. Searles-Wood, F.R.I.B.A., who opened the discussion, took the opportunity to emphasise the importance of the cement bags being properly marked and labelled with the maker's name, a point which both the Royal Institute of British Architects advocated when dealing with reinforced concrete, and the Cement Standards Committee recommended when issuing their Report last year.

THE DANGERS OF "NATURAL CEMENTS."

Another point that claims attention was Mr. Fox's answer to an enquiry from Mr. Max Clarke, F.R.I.B.A., as to the failure of a certain concrete floor, where the failure was attributed to cement. In putting his question, we were, by the bye, glad to observe that Mr. Clarke joined issues with the large number of misinformed people who at the present time, *ipso facto*, attribute all concrete failures to the Portland cement used. Mr. Clarke rightly indicated that he considered that in the great majority of cases the engineers and the architects had made rather a mistake in attributing the failures to that material. He thought it more than probable that a large proportion of them were attributable to the aggregate. We fully agree with his views, but think that bogus Portland cement, *i.e.*, Natural cement, is also frequently the cause of trouble.

Mr. Fox, in his reply, stated that the case Mr. Clarke enquired about the cement used was not genuine Portland cement, but the so-called *Natural* cement, and thus Portland cement was fully absolved. This dangerous natural product is imported from the Continent, and its sale under the name of "Portland" cement is one of those abuses which were formerly equalled by the sale of margarine for butter, an abuse rightly legislated against.

Thus we would quote the damning views of such an eminent authority as Mr. Francis Fox in *Natural* cement. His words were to the effect that:—

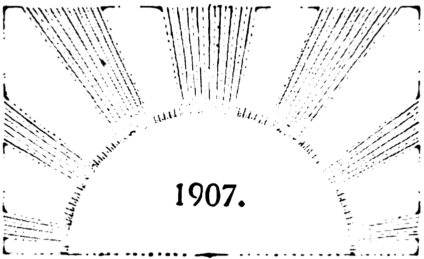
> "Natural cement simply meant a cement in which Nature had not worked a true chemical analysis, and that the cement stone from which it was taken in one place was different from what it was in another. Consequently natural cement was a dangerous thing to use. *Nothing would ever induce him to touch it.*"

We trust Mr. Fox's condemnation will be taken to heart.

CONCRETE AND OUR NAVY.

The man in the street is hearing much at present of questions of policy relating to the increase of the Navy. We should like to seriously point out to the powers that be that no matter what the policy is as to the increase of our ships, all concerned in harbour works have for some years been alive to the fact that insufficient progress is being made in the construction of docks to meet not only the requirements of our Navy, but also those of our ocean greyhounds which are yearly increasing in size and tonnage, and are to form an auxiliary to our Navy in case of need. We may or may not require more ships, but it is an indisputable fact that for the ships existing, or in course of construction, the dock accommodation on our coasts is all too insufficient. Further, it is a fact that the period of construction for a first-class dock is longer than the period of construction for a first-class battleship. It is thus becoming a matter of most urgent need that the leeway in dock construction should be made up with celerity, in fact, that the necessary works should be promptly put in hand.

The issue as to whether more ships are required or not is one of general interest. The picture of a warship appeals readily to the general public. The dock question, however, is one that is essentially technical, and one to which the man in the street gives little thought. We trust, however, that the man in the street may also some day become more alive to the fact that ships without sufficient dock accommodation are expensive and hazardous luxuries, and that he will call as loudly for the docks necessary for the ships as for the ships themselves.



THE "ADVANCE" IN THE CONCRETE AGE.

By Lieut.-Col. J. WINN, R.E., A.Inst.C.E.

In the following article the author summarises the principal features of 1907 as far as the development of reinforced concrete in Great Britain is concerned.

The progress has been steady and extensive, and if perhaps not quite as remarkable as in 1906, it has nevertheless been of more lasting importance.

Such a decision as that of Sir Henry Tanner to build the new General Post Office extensions and various smaller Post Offices of reinforced concrete will have a far-reaching effect, and a report such as that of the Reinforced Concrete Committee will be most beneficial for years to come.

It is to be hoped that regardless of the somewhat lesser aggregate of general building work to be expected in 1908 than at the commencement of normal years, the progress of reinforced concrete will continue to be satisfactory. A period of economy and "tightness of money" should, in fact, advantageously affect the use of a material the employment of which almost invariably means money saved.—ED.

As one reviews the past year in relation to the advance which has been noticeable in the use of concrete, and especially reinforced concrete, one is struck with the progress which has been made in:

1. The spread of the knowledge of the subject;
2. The variety and number of the structures which have been executed in this material; and
3. The number and the character of the individuals and public bodies who have adopted its use.

A few words under each of these heads, summarising the events of the year, may serve to point out in which direction this advance has been made.

1. The Spread of Knowledge of the Subject.

On the Continent, where reinforced concrete has been more extensively used than in this country, there have existed codes embodying the conditions, permissible stresses, etc., for the guidance of engineers, architects, and others interested in building operations, under which reinforced concrete might be used. These codes have now been in force for some years, and designers and builders in the district to which they apply have been bound to observe these regulations when dealing with this material.

In this country, however, no authoritative voice had been raised, and in the absence of any definite instructions, "every man did that which was right in his own eyes," the results being many and various, leading in some cases to needless extravagance, while, on the other hand, there was a danger that the conditions which were essential to safety were not being observed.

Under these circumstances the Royal Institute of British Architects invited the Government Departments and several other kindred societies to co-operate in forming a committee to enquire into the subjects of reinforced concrete, and to issue a report which might be a guide to all concerned. One of the objects of the report was to obtain in Great Britain a greater uniformity in the permissible stresses to which structures in this material should be subjected, and, further, it was intended to state the conditions under which these buildings should be erected, with due regard to the public safety.

This report was issued in the early part of 1907, and although it does not possess that power to insist on its provisions enjoyed by the foreign codes referred to above, still it was decidedly a step in the right direction. It was purposely made as simple as possible, so that designers and builders generally—who do not lay claim to any very deep mathematical knowledge—might have in their hands a guide which they could consider as thoroughly reliable, and there is no doubt that the result has been extremely satisfactory. In fact, the Report of the Reinforced Concrete Committee has furnished a sound basis upon which thoroughly practical buildings may be designed. It should also be remembered that although the Report was issued in this simple form, it embodied the results of investigations made in every country where research work had been carried out in regard to the behaviour of reinforced concrete under differing conditions, and in a way the Report embodies a summary of the world's knowledge on the subject, say, up to the spring of 1907.

It is, perhaps, regrettable to have to confess that so much of the information embodied in the Report had to be sought for outside the confines of the British Empire; but, curiously, we cannot yet boast of possessing the necessary means and appliances at our seats of learning which are considered the essential equipment of the Universities and Technical Colleges on the other side of the water, for the investigation of structural materials and systems of construction. We have thus been dependent to a great extent on the labours of our American cousins for the information and data which have been incorporated in the Report, and which have been carefully compared with similar experiments on the Continent.

This want of both the necessary funds and the properly equipped installations for the purposes of research in matters appertaining to engineering and building construction is greatly to be deplored, and seems to reflect upon the great public departments of this country, who are, in this respect, lagging behind the example of our more enterprising rivals in the competition for commercial supremacy.

In one department, however, which had special bearing upon this enquiry into reinforced concrete, we may claim to be second to none, and superior to most, if not all, of our foreign rivals. In the investigation of building materials and systems of construction under the effect of fire there is no doubt that the results of the tests carried out by the British Fire Prevention Committee are considered the most reliable, and have done more to establish what is really fire resisting than all the so-called "tests" which have been carried out by more or less interested parties.

The fact that all their tests are independent of any financial interest in the results, and that they are conducted most carefully by thoroughly qualified men, with a suitably equipped plant, sufficiently large to make the tests "life size," and that the Reports are published without "partiality, favour, or affection," has ensured that the conclusions arrived at by the British Fire Prevention Committee are received with confidence on all sides, and their researches have gone far to dissipate false notions as to what may really be accepted as giving adequate protection under different conditions of fire intensity.

That this work is carried on by the zeal and enterprise of private individuals, absolutely gratuitously, speaks well for them, but, nevertheless, it does seem strange that this work, which is of national interest, should be unsupported by public funds, and left to private initiative, instead of being carried out under the direction of a Government Department.

The executive of this committee has convened a special commission, composed of representative members, to investigate the subject of concrete aggregates, both as regards their resistance to fire, and their capabilities to withstand stresses, and also to elaborate specifications which will enable architects and engineers to obtain what they want to carry out their designs with more uniformity than at present, for, though it may be impossible to standardise such a material as concrete, the existing confusion renders it difficult, if not impossible, for those responsible for designs, and the contractors who carry them out, to arrive at a clear understanding as to what is really required. It is to be hoped that the result of the labours of this Special Commission on Concrete Aggregates, which is now charged with this matter, will greatly facilitate the execution of works and remove misunderstandings which give rise to friction and dispute, and that at the same time the Commission may arrive at such data as will ensure that the materials used as the aggregates for concrete, especially in reinforced work, will resist the stresses to which they will be subjected.

The Commission is specially convened to deal with *aggregates*, as the matter of the *cement* has already been under consideration by the Engineering Standards Committee, who have during the past year issued a revised specification, which is a decided advance of that issued in 1904, though it may be considered as an intermediate one, for the Committee are still making investigations which will most probably necessitate still further amendments in the specifications. The old one, though most useful at the time of its publication, was hardly up-to-date, especially in the clause which dealt with fineness of grinding.

The paragraph of the Portland Cement Specification, issued in 1907, which has been hailed with the greatest satisfaction by cement users, is that which provides for all packages to be delivered "marked with the manufacturer's name," and it is hoped that this new rule will go far to prevent the importation of inferior natural cement, and the sale of worthless stuff, which has been sold as "Portland," but is so only in name.

In connection with the spread of knowledge, reference should be made to the fact that three papers were read at last year's Engineering Conference, two at the meeting of the British Association, and a number of others were delivered by specialists at the minor technical societies. It was also a sign of the times that a lecture on reinforced concrete was delivered at the Machinery Exhibition. Quite a number of articles have been appearing monthly, if not weekly, in the journals and magazines which cater for those interested in architecture and engineering, whilst one architectural journal has been publishing a regular concrete supplement, and several papers publish special reinforced concrete supplements. There have been several new books on the subject, and of late even the daily press has been giving the question a certain amount of attention.

It may well be asked what is the sum and substance of the researches which have been made, and how much new light has been shed on the subject? Taking a broad view of the year's work there does not appear to be any specially startling discovery, but the experiments have rather resulted in confirming the investigations of previous years, which should tend to increase the confidence of the public in this form of construction, for it should be remembered that great claims have been made for this material, and it is satisfactory to find that the more thoroughly it is tested with the most efficient appliances the results show that the reliance that has been placed in it by the pioneers of reinforced concrete has not been misplaced.

With regard to fire protection, it has now been established that the steel must be *amply* covered, and that with the kind of concrete which is found to be the best fire resister. In the early days it was practically claimed that if the work would stand the load it could be depended on to stand fire, and a great deal was made of the fact that the co-efficient of expansion was practically the same for both the steel and the concrete. from which it was argued that there could be no fear of the two materials becoming dissociated under the effects of heat. The rates of absorption and conductivity are, however, very different, and this difference must not be lost sight of in considering the action of the combined materials under high temperatures; in fact, the difference points to the necessity of having the steel well protected. The loss of strength of steel under high temperatures has been long recognised, but it is only comparatively recently that the degree of loss of strength of the concrete under fire conditions has been investigated, which has induced many to modify their opinions, formed before this further light was thrown on the subject.

2. *The variety and number of the structures which have been executed in this material.*

Under this head we consider the new uses that reinforced concrete has been put to, and these are so numerous that the question arises: To what has it *not* been applied? And now, instead of looking upon reinforced concrete with suspicion or contempt, as was formerly the case, it has become customary to consider the feasibility of executing buildings and engineering works in this material in preference to others.

The economy of time and money which results from its use is becoming generally recognised, and where the purposes of the structure are rather utilitarian than artistic, its advantages are found to outweigh other materials very considerably. Officially, the saving obtained by H.M. Office of Works by the use of reinforced concrete is stated to be 20 per cent. Private users have attained savings up to 33⅓ per cent. in plain factory and warehouse work.

In the appendix of a book issued during 1907, 450 structures are enumerated, exclusive of floors (which are too numerous to mention), that have been recently built of this material in the United Kingdom, and from the notices that appear in the Press it will be seen that it has been used for almost every conceivable purpose, for bridges, baths, and barracks, for churches, chimneys and conduits, for foundries and factories, for piers and palaces, power stations and post offices, for sewers and silos, for seawalls and swimming baths, for reservoirs and railway-sleepers, for walls and wharves, weirs and warehouses, for aqueducts and viaducts, etc., etc.

For the huge masts that are required to equip the great wireless telegraphy station, designed to communicate with America, reinforced concrete has been suggested, and among the more recent uses to which it has been applied to meet an up-to-date requirement, reference might be made to the Brooklands Motor Track, where it spans the river Wey.

But perhaps the decision to execute the extension of the General Post Office in reinforced concrete has caused the greatest interest in this material, and has been the principal event in its history for 1907. The importance of the building, and the position of the great public department for which the building will be employed will undoubtedly encourage the use of reinforced concrete among many who may hitherto have hesitated in considering it a desirable addition to the materials in which public buildings may be erected.

3. The number and character of the individuals and public bodies who have adopted reinforced Concrete.

There has been a noticeable advance in this direction, and reference to the publications of the year will show that large private firms, whose operations and interests are on a par with public departments, have recognised its adaptability for many purposes, and have adopted it in their works, which, being run on a commercial basis, ensure that there has been due regard paid to its financial aspect.

Large and important corporations, such as railway companies and harbour boards, have been making extensive use of it, and visits to such centres as Manchester and Liverpool, Newcastle and Southampton, demonstrate how its employment is increasing among engineers who are responsible for the works carried out by these great bodies, and should inspire confidence on the part of others who may have similar work to perform.

The representatives of three of the Government Departments have announced in the House that they are satisfied with the results of its employment in the works under their direction, both as regards economy and efficiency, and it is understood that the other Goverment Departments concerned in the carrying out of building operations on a large scale are also convinced of its practical utility and durability.

Coming now to other public bodies, such as County, District, City, Borough, and Parish Councils, we find that there is an increasing desire to make use of that which they hear on all hands is being used by similar bodies on the Continent, but as they are dependent on funds raised by rates, they are restricted by regulations which have been introduced to safeguard the interest of the public, and up to the present those responsible for these regulations have not satisfied themselves that reinforced concrete is sufficiently durable to justify its use, where a longer life than fifteen years is considered. As long as this opinion is held it is evident that the Councils mentioned above are debarred from adopting a material the use of which is adopted and sanctioned by the authorities mentioned above, and are in a measure prevented from effecting the economies which its employment ensures, and must therefore depend on more costly forms of construction, so that in the desire to safeguard the public the interest of the public apparently suffers.

Such is the demand for this material on the part of Councils who are desirous to carry out their works with due regard to economy that, in spite of the restrictions referred to, we find in the list of buildings and works that many have been constructed of reinforced concrete out of revenue, or under the disadvantageous loan conditions referred to, and this tendency to use reinforced concrete would certainly be greatly increased if the Councils had a free hand.

It is abundantly recognised that those responsible for the protection of the public must make such rules as will ensure that their interests do not suffer by expenditure on that which will not answer its purpose, but there is a general expression of opinion that this very carefulness may defeat its own object by necessitating a greater expenditure than is really required.

It is therefore to be desired that in view of the experience which is daily increasing, the existing regulations may be so modified as to permit of the adoption of reinforced concrete for public works, which could be more economically carried out with it than with any other material, both as to first cost and also as to maintenance, for it should be remembered that its use does away with the current expenditure for upkeep, which forms no inconsiderable item in the annual expenses of a community.

No mention has been made of the host of small users of this combination of concrete and steel, which is so well adapted to the hundred and one small jobs that are always occurring, but a fairly extensive knowledge of what is being done by men in a small way of business reveals that now the principles involved in its use are becoming understood there is a growing desire to avail themselves of its advantages. It might be as well, however, to reiterate what has been so frequently urged before, that to obtain the results which are claimed, and which have been obtained elsewhere, two things are essential—*good materials* and *care*.

The Future.

Sufficient has been said to show that there has been a very real advance in the adoption of reinforced concrete in this country, and there is every indication that this advance will be maintained

Prejudices are being removed, knowledge is being increased, principles are becoming understood, and with all these will come a more extensive field for its employment; this in its turn will enlarge our knowledge of its capabilities, and with this knowledge will come a further demand for its use.

REINFORCED CONCRETE FOR POST OFFICE BUILDINGS

Probably one of the greatest events of 1907 as far as reinforced concrete is concerned, was its official adoption by H.M. Office of Works for Post Office Buildings, and its specification for the new General Post Office at St. Martin's-le-Grand.

It should be understood that besides this gigantic extension, reinforced concrete will shortly be used in a number of other Post Office buildings executed under the direction of the same authority, and in this issue we are presenting two instances, one of the new Post Office Building at Manchester, the other of the new Telegraph Stores at Birmingham.—ED.

In a previous issue we referred to the extensive work that is being undertaken in reinforced concrete at the General Post Office, where Messrs. Holloway Bros. hold the contract for the extensions, aggregating several million cubic feet, the system being that of Messrs. Hennebique. The work is being executed under the direction of Sir Henry Tanner, I.S.O., Mr. L. G. Mouchel, the general agent for Messrs. Hennebique, acting as specialist consultant.

The building is one of considerable interest, apart from any question of extent, and it has rightly been recently the object of visits from important technical societies, including the Institution of Civil Engineers.

Reinforced concrete is, however, now being applied in other parts of the country for Post Office work, as also in buildings for the Telegraph Department, which is under the control of the General Post Office.

Notable among these instances are the new Manchester Sorting Office, in which the Hennebique system is being applied; the South-Western Post Office, London, in which the Coignet system is being used; and the various blocks of the Central Telegraph Stores at Birmingham, of which two are being executed by the Cubitt Concrete Construction Co., on the Kahn system.

Of the Manchester Post Office we have received a detailed description, by permission of H.M. Office of Works, from the hands of Messrs. Mouchel & Partners, Ltd., and this description we publish below. Similarly we have received from Messrs. Cubitt Construction Co. some illustrations of their work at Birmingham. The third instance above-named we shall deal with in a future issue.

It is certainly a matter of congratulation that such characteristic examples of reinforced concrete work in public buildings are now available for illustration in this country, and we think we should take this opportunity to say that the Office of Works and their principal architect are to be specially congratulated on the far-seeing way in which they have taken up this matter, in a manner which, as stated only last session in Parliament, will mean a substantial saving to the British taxpayer in the national expenditure on buildings of this description.

MANCHESTER POST OFFICE.

The Post Office work at Manchester comprises an extension of the Post Office at Oldham Road, which extension is to be principally used for letter sorting. Mr. W. Pott, of H.M. Office of Works, is specially charged with this building, in which the reinforced concrete system applied is that of Messrs. Hennebique, Mr. L. G. Mouchel again acting as consultant, and the contractors being Messrs. E. Nuttall & Co., of Manchester.

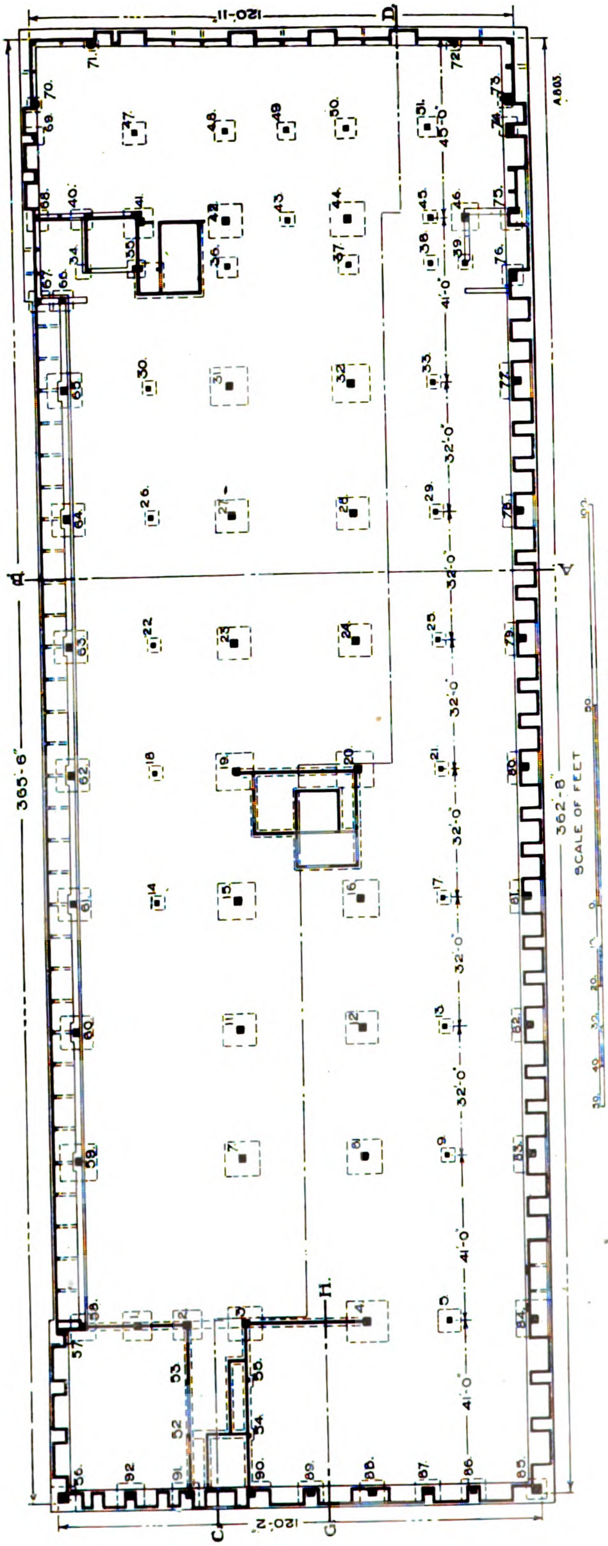


Fig. 1 Manchester Post Office Basement Plan.

The building will be 362 ft. 8 in. long by 120 ft. 2 in. wide by 50 ft. high from street level, or 56 ft. high from basement floor level. It will have two suspended main floors, two mezzanine floors, and a flat roof, calculated as a floor. The basement floor, at the average depth of about 6 ft. below street level is of ordinary concrete, but the sides of the excavation are held up by reinforced concrete retaining walls, 6 in. thick.

The general idea of the structural design is that of a framed building, on what is sometimes quite erroneously called the "American" system, the fact being that framed buildings were put up in this country many years before America was discovered.

All the dead weight of the new post office, and all dead and live loads due to its contents, will be carried by the floor slabs and floor beams, and transmitted by them to interior columns, wall lintels, and wall columns.

Thence the loads will be transferred to the extended column bases and distributed over the ground at the rate of not more than 5 tons per sq. ft.

One very great advantage gained by the system of frame construction is that the outer walls of the building have no weight to carry, and therefore can be made very thin, or only just thick enough to keep out the weather, and to prevent excessive conduction of heat from the exterior in warm seasons of the year.

The outer wall panels will be only 14 in. thick, which means a great saving of space, owing to the reduction of wall thickness from that called for in ordinary construction. There will also be a good saving from the reduced thickness of the interior walls, which are 4 in. in some cases and 6 in. in others.

The floor girders are of long spans and comparatively small depth, and the floor slabs only require to be 3½ in. thick. Thus here again there is a notable increase of interior space.

The drawing reproduced in *Fig.* 1 is a general foundation plan, showing the positions of the 92 reinforced concrete columns intended for supporting the superstructure.

Table 1 gives the cross-sectional dimensions of the various columns, the sizes of which range from 10 in. by 10 in. to 32 in. by 32 in.

TABLE I.

DIMENSIONS OF REINFORCED CONCRETE COLUMNS, NEW POST OFFICE, MANCHESTER.

Size in Inches.		Numbers of Columns. (See *Fig.* I.)
10 × 10	....	52, 53, 54, 55.
14 × 14	....	5, 9, 13, 14, 17, 18, 21, 22, 25, 26, 29, 30, 33, 38.
16 × 16	....	34, 35. 36, 37, 39, 43, 45, 47, 48. 49, 50, 51.
16 × 18	....	40.
18 × 18	....	66, 67, 68, 69, 74.
18 × 32	....	57.
24 × 24	....	1, 2, 3, 4, 7, 8, 11, 12, 15, 16. 19, 20, 23, 24, 27, 28, 31, 32. 41, 42, 44, 46, 58, 60, 61, 62, 63, 64, 65, 86, 88, 89, 90, 91, 92.
22 × 32	....	75, 76, 77, 78, 79, 80, 81, 82, 83, 84.
27½ × 27½	....	56.
32 × 32	....	85.

As inspection of the foundation plan will make clear, the footings or bases of the columns vary in dimensions, the actual superficial area being dictated by the loads to be carried.

In the following table the dimensions of the slabs under the columns are stated :

TABLE II.

DIMENSIONS OF REINFORCED CONCRETE COLUMN BASES, NEW POST OFFICE, MANCHESTER.

Sizes.						Area in Sq. Ft.		Numbers of Columns. (See *Fig.* I.)
ft.	in.		ft.	in.				
2	6	×	2	6	....	6·25	....	52, 53, 54, 55.
3	6	×	3	6	....	12·2	....	9, 22, 13, 14, 17, 18, 21, 25, 26, 29, 30, 33, 34, 38, 39, 43, 45, 70, 71, 72, 73.
4	3	×	4	3	....	18·1	....	35, 49.
4	6	×	4	6	....	20·1	....	69, 74.
5	0	×	5	0	....	25·0	....	36, 37, 40, 48, 50, 51, 66, 67, 68, 75, 76, 85.
5	6	×	5	6	....	30·2	....	5, 47, 56, 57.
6	0	×	6	0	....	36·0	....	86, 87, 88, 89, 90.
6	6	×	6	6	....	42·2	....	58, 91, 92.
6	9	×	6	9	....	45·5	....	46.
7	0	×	7	0	....	49·0	....	1, 2.
7	3	×	7	3	....	52·5	....	41.
8	0	×	8	0.	....	64·0	....	11, 12, 23, 24, 27, 28.
8	3	×	8	3	....	67·5	....	3, 42, 60, 61, 62, 63, 64. 78, 79, 80, 81, 82.
8	6	×	8	6	....	72·0	....	7, 8, 44. 65, 77.
9	0	×	9	0	....	81·0	....	15, 16, 19, 20, 59, 83, 84.
9	3	×	9	3	....	85·6	....	31, 32.
10	0	×	10	0	....	100·0	....	4.

It should be noted that the underside of all the column bases is 3 ft. 6 in. below basement level, that the underside of slabs below internal partitions is 1 ft. 6 in. below basement level, and that the top of the slabs under the external walls is at basement level.

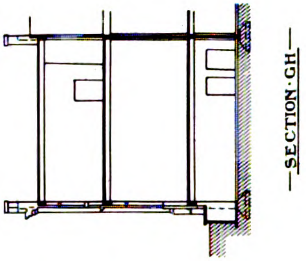


FIG. 4

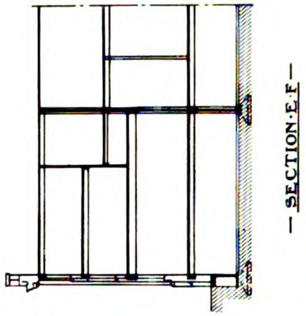


FIG. 8.

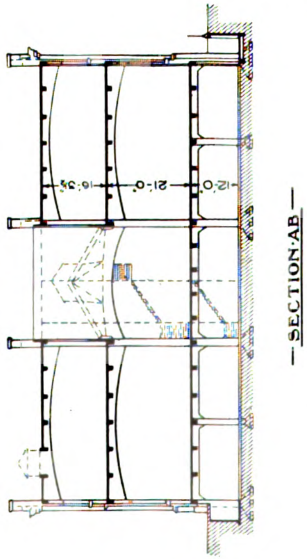


FIG. 2

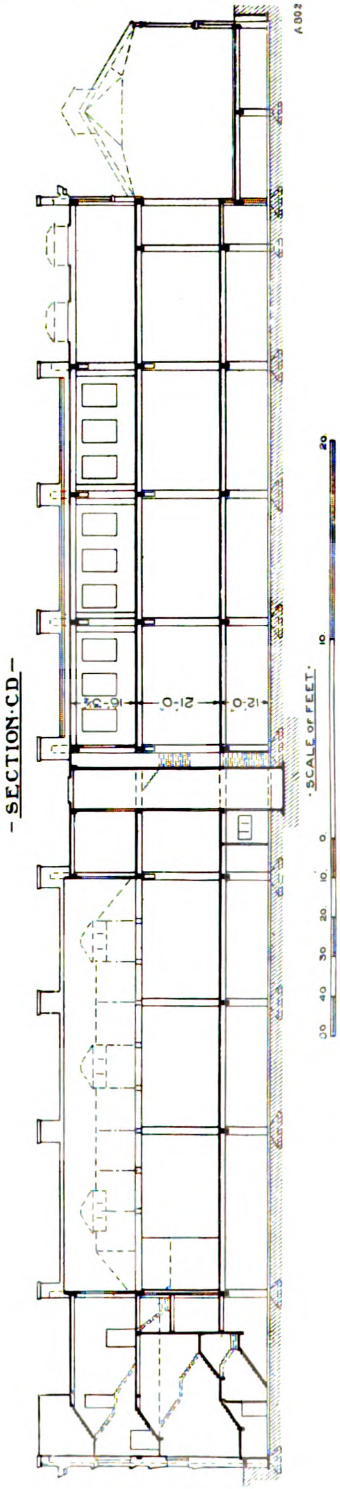


FIG. 3. MANCHESTER POST OFFICE (various sections).

Another point which deserves to be mentioned is that the foundations and columns throughout are designed of sufficient strength to carry the weight of two additional storeys, so as to provide for future increase of the accommodation at present contemplated.

The sections on lines A B and C D (*Figs.* 2 and 3) will help the reader to form a fairly accurate idea of the building.

Looking first at the cross section (*Fig.* 2), we see that on this line the building is divided above the ground floor into three parts, two on the outside, with three floors in all, and a flat terrace roof, and one in the middle with two floors and a ridge roof.

This drawing makes clear the arrangement of the column bases, and explains why some of the columns are of such small dimensions and require such small bases.

The main arched beams between the outer wall columns and the two rows of inner columns in the first floor and roof are of 38 ft. clear span which, although surpassed in several noteworthy buildings previously erected in reinforced concrete, is nevertheless very large, and shows the particular adaptability of this method of construction for exceptional cases where intermediate supports are thought undesirable.

Looking next at the longitudinal section (*Fig.* 3), the first part at the left hand shows the stairways at the front from top to bottom of the building.

The next part of the drawing is a section along the centre line of the middle portion of the building, and shows the three roof lanterns giving light to the fine hall on the first floor.

Then comes a portion where the floors are carried up to the same height as in the two outer divisions of the building, and after it to the lift-well and stairways.

Continuing inspection to-

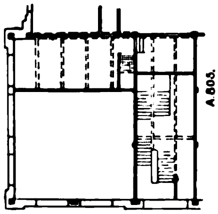


Fig. 7.

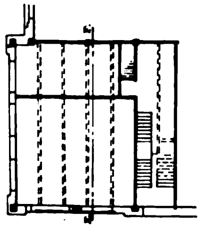


Fig. 6.

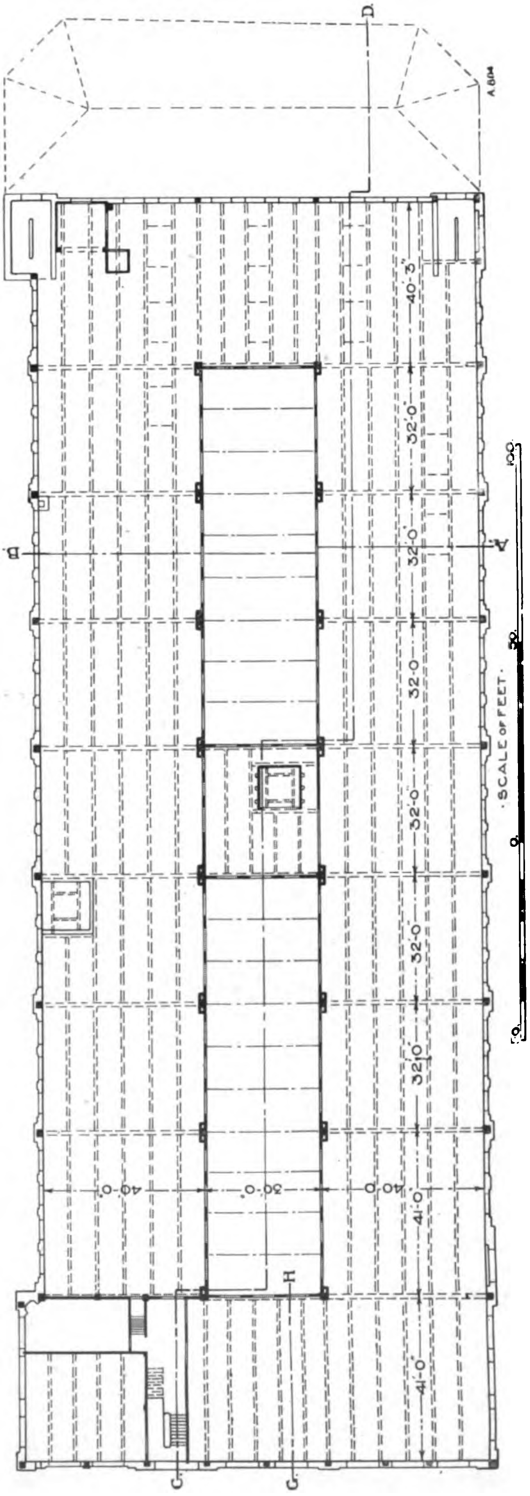


Fig. 5. Manchester Post Office.
(Principal floor.)

wards the right hand of the drawing, we come to a longitudinal section through one of the outer divisions, where there are four floors in all, and beyond that a loading platform for vans, with reinforced concrete floor over a portion of the basement and covered by a steel truss roof.

A drawing illustrating the arrangement of the front part of the building is the part longitudinal section on the line G H (*Fig.* 4).

Here, as at the extreme end of the building and halfway between the two extremities, there are four floors and a flat roof, as in the two outer portions shown in *Fig.* 2.

A still better idea of the building is given by Fig. 5, which is a plan of the first floor showing the beams of the ceiling above, or, more correctly, the beams of the terrace roof.

This drawing indicates that the whole structure may be described as a building with two interior courts, simply roofed over as shown in *Fig* 2.

The point deserves to be noted, for it emphasises the fact that the great arched beams of 38 ft. span in the two outer portions of the structure are genuine beams and not arches in any sense of the word.

Consequently, there is no horizontal thrust at first floor or roof level in the main columns, and the principals of the roofs covering the two courts are perfectly independent of the reinforced concrete construction, save in the respect that the columns and beams of that material give to them an additional guarantee of safety, by acting as rigid abutments at either end.

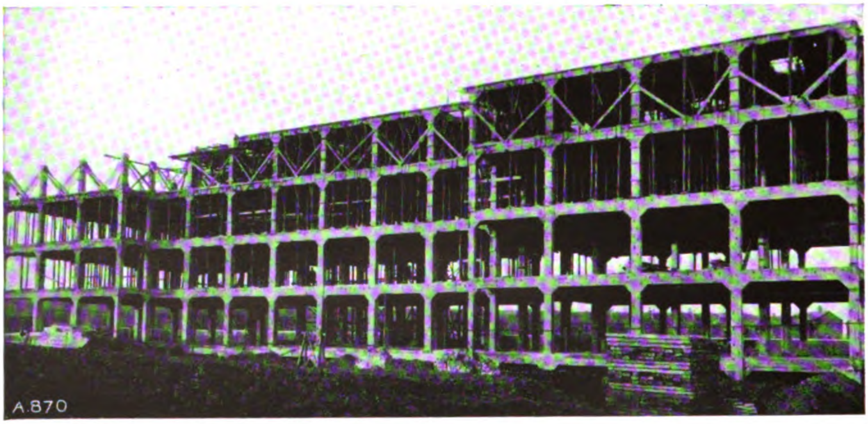


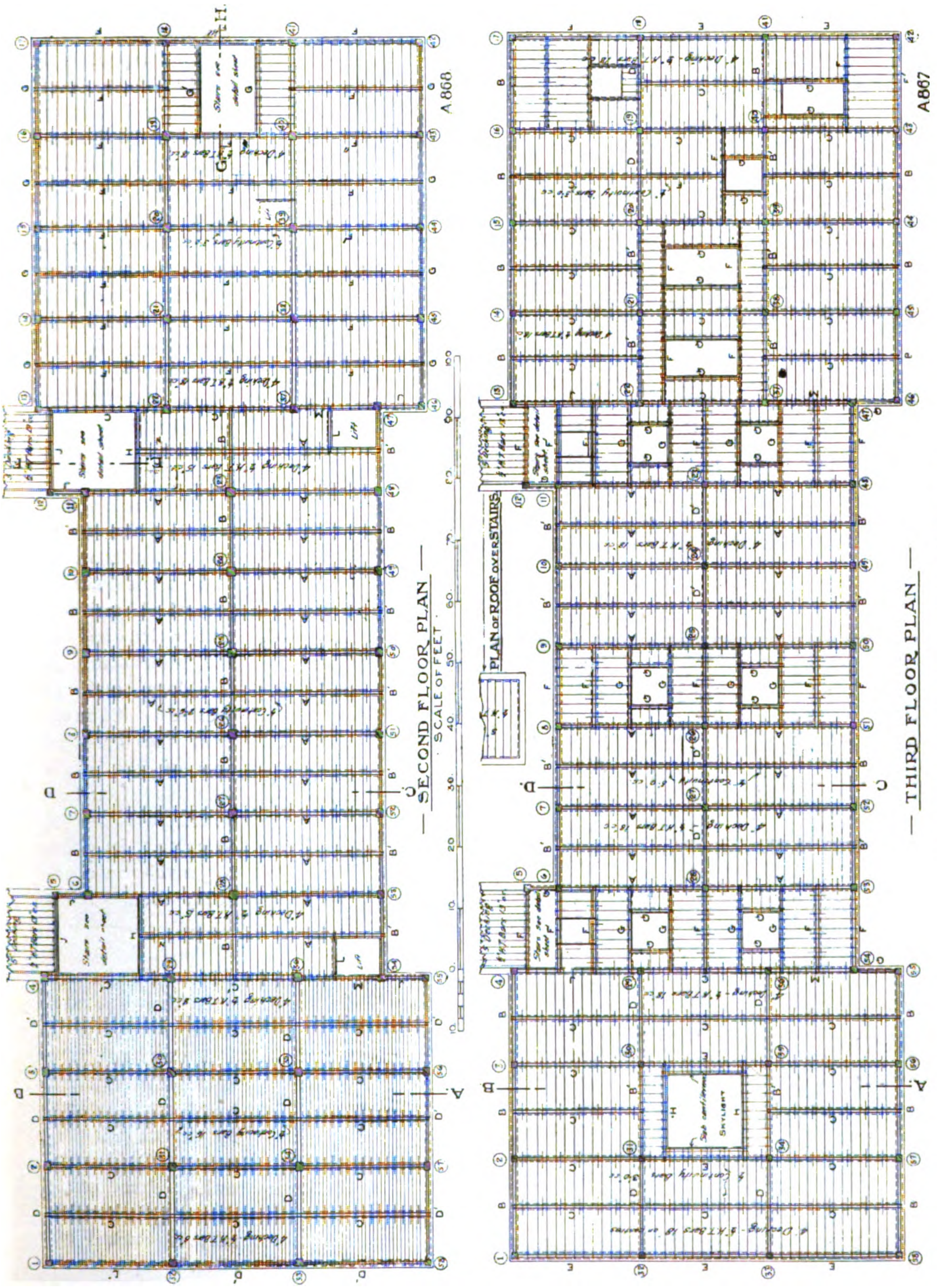
FIG. 9. TELEGRAPH STORES, BIRMINGHAM.
(Exterior view.)

At the top left-hand corner of *Fig.* 5 there is a small area denoting the position of two mezzanine floors, one above and the other under the first floor, the position of the latter being further indicated in *Fig.* 2.

Plans of these floors are given in *Figs.* 6 and 7, where also are some details of the reinforced concrete stairways.

Fig. 8 is a section on the line E F in *Fig.* 6, further illustrating the arrangement of the mezzanine floors.

All the structural features of the reinforced concrete work follow the customary practice adopted in the Hennebique system.



FIGS. 10 AND 11. TELEGRAPH STORES, BIRMINGHAM.

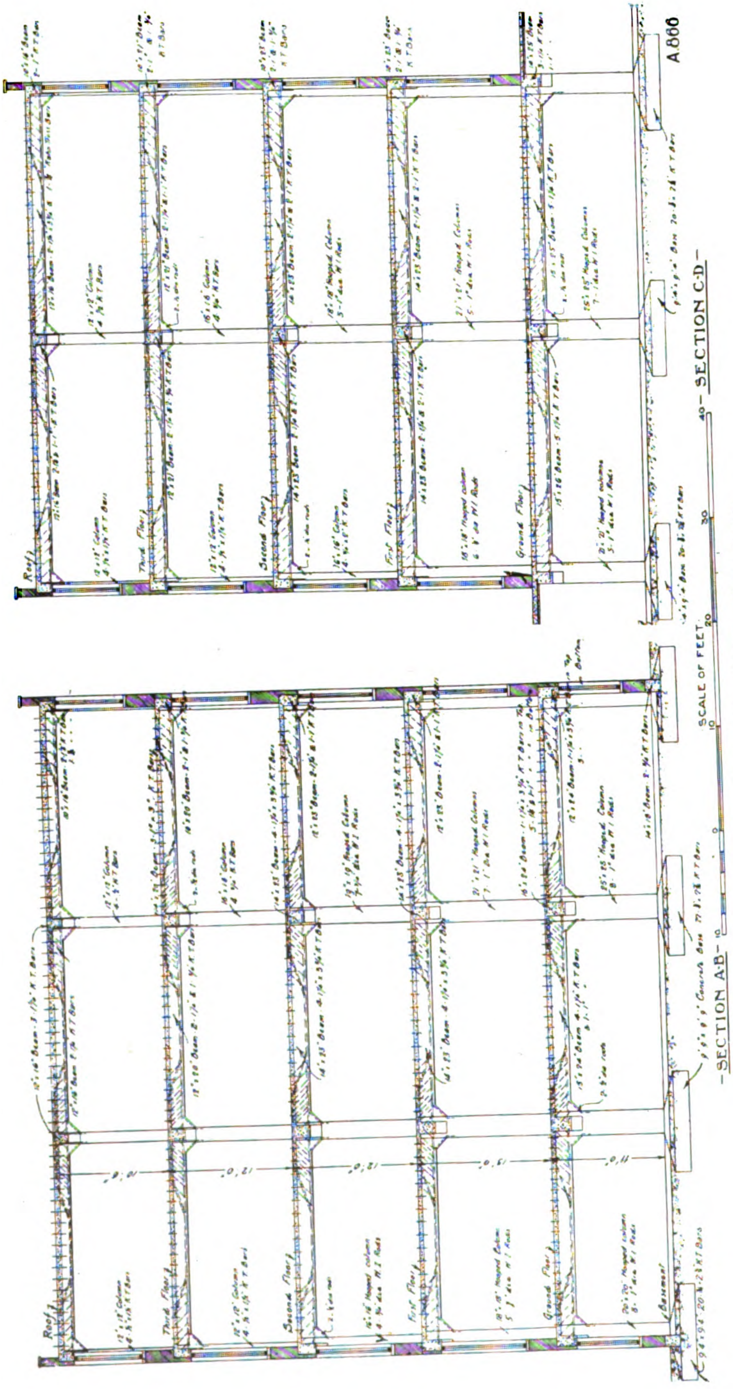


FIG. 12. TELEGRAPH STORES, BIRMINGHAM.
(Sections showing Kahn bar reinforcement.)

Similarly, as the working plans and sections reproduced in the illustrations to this article show very clearly the arrangement and dimensions of all the chief members of the construction, it is hardly necessary to occupy space by minute description of the column and floor details.

The site of the new building was formerly occupied by a mill, and, during the work of excavating the basement, the contractors came across several old culverts and wells, one of the latter being 70 ft. deep and of greater diameter than the base of one of the main columns under which it happened to come. In order to provide an absolutely secure foundation for this member, it was decided to fill the well up with rough concrete.

A very complete installation of plant has been laid down by the contractors, a particularly interesting fact being that all the machinery is worked by electric power. Stone-breaking and concrete-mixing plant of the latest types are being used, and electric hoists are in operation for raising the concrete to the various floors.

Work was commenced in October last, and it is expected that the building will be completed well within the contract time, which expires in August this year.

THE NEW TELEGRAPH STORES, BIRMINGHAM.

As to the Telegraph Stores at Birmingham, the building illustrated is one of a range of five which are being erected for the General Post Office Telegraph Department, and, as stated before, the first two of these are being executed by the Cubitt Concrete Construction Co., of London, the system of reinforced concrete adopted being that of the Trussed Concrete Steel Co., Ltd., known as the Kahn system, and the architect, Mr. John Rutherford, of H.M. Office of Works.

The photographs comprise an exterior view (*Fig.* 9) and an interior view (*Fig.* 13) of one of the floors, and speak for themselves, and if examined in conjunction with the plans of the second and third floors (*Figs.* 10 and 11), which we present, together with some sections (*Fig.* 12), will give a general idea of the method of construction applied.

The system of the Kahn bar reinforcement, adopted throughout, needs no special explanation on our part, as it is well known, and the sections in particular show how the beams have been designed, the necessary particulars and figures being indicated with commendable elaboration.

We hope, in a future issue, when the first two blocks have seen completion, to be able to present some additional illustrations with particulars of these very interesting buildings.

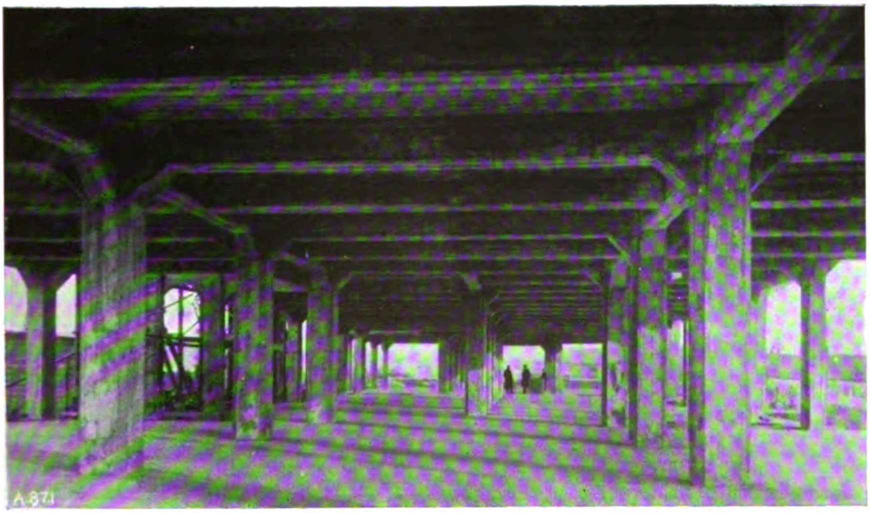
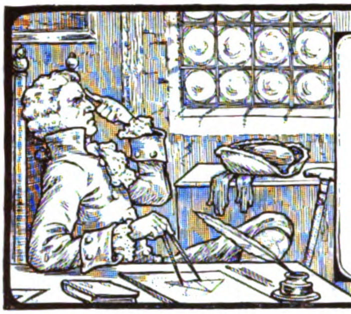


FIG. 13. TELEGRAPH STORES, BIRMINGHAM.
(Interior view.)



THE ROYAL INSTITUTE OF BRITISH ARCHITECTS AND H. M. OFFICE OF WORKS ON REINFORCED CONCRETE

As already indicated in our Memoranda of the last issue, an important communication of far-reaching importance for reinforced concrete was recently addressed by the Royal Institute of British Architects to one of our Government Departments, in reply to an enquiry on the subject.

The name of the Department and the terms of the reply were not public property at the time of our going to press, but it was soon afterwards known that the Department was H.M. Office of Works, and the communication took the form of a letter expressing the opinion of the Royal Institute of British Architects on the stability of reinforced concrete as compared with other materials.

This correspondence is of such importance that we publish it with a few remarks on our own part.—ED.

We have frequently referred to the attitude of the Local Government Board when loans are applied for by local authorities, and the extraordinary fact that reinforced concrete is not classified as being of equal durability as ordinary materials, such as brick and timber. In fact, we might say that according to some extraordinary measuring instrument kept by that department, the life of reinforced concrete is registered at only 50 per cent. of that of ordinary materials.

The attitude of the Board is the more remarkable having regard to the important structures being erected by H.M. Office of Works, in reinforced concrete, as also from the fact that both the Admiralty and the War Office utilise this modern form of construction. Further, as has been pointed out to us by an eminent authority on the subject, these departments have practical experience of the subject on their own works, whilst the Local Government Board can at the most speak academically or as theorists.

We congratulate not only the Royal Institute, but its Science Committee and the members of the committee who drafted the reply, on the clear and concise way in which the facts of the case have been put. We trust that the views of the Royal Institute of British Architects, and the fact that several Government departments are utilising reinforced concrete on a considerable scale, has by this time been formally brought to the knowledge of those responsible for the conduct of the Local Government Board, for we fail to see how, when this information has really been *formally* put before them, the officials of that Board can continue their policy of handicapping local authorities desirous of being economical in their expenditure, and utilising the form of construction which is obviously a money-saver for many of their purposes.

To our knowledge the dissatisfaction of the local authorities and their technical officials is increasing all over the country on this particular matter, and we sincerely trust that—subject to due and reasonable regulation—an end may soon be seen of what is literally making this country a laughing stock among the technical professions abroad.

As to the correspondence itself, we have little to say, except that we are somewhat surprised that H.M. Office of Works should in the first instance when addressing the enquiry still have spoken of reinforced concrete as "ferro-concrete," after the term "reinforced concrete" has now long been generally adopted as descriptive of the material.

THE ROYAL INSTITUTE OF BRITISH ARCHITECTS ON REINFORCED CONCRETE.

The following correspondence has passed between H.M. Office of Works and the Council of the Institute :—

H.M. Office of Works, Storey's Gate, S.W., 31st July, 1907.

SIR,—I am directed by the First Commissioner of His Majesty's Works, &c., to state that this Department is informed that in the opinion of the Local Government Board buildings constructed in ferro-concrete are likely to prove less durable than those of bricks and mortar, and that that Board are re-arranging accordingly the rates at which money is to be advanced for the erection of the first-mentioned class of building.

In view of the foregoing I am to say that Mr. Harcourt would be much obliged if you will be good enough to favour him with the opinion of the Royal Institute of British Architects on the subject.—I am, Sir, your obedient servant,

J. FITZGERALD.

The President R.I.B.A.

The foregoing letter was referred by the Council to the Science Standing Committee, and the Committee's report will be found embodied in the following reply of the Council :—

9th December, 1907.

To the Right Hon. Lewis Harcourt, M.P., First Commissioner of Works.

SIR,—The Council of the Royal Institute have had under consideration the letter of the 31st July addressed by His Majesty's First Commissioner of Works to the President, stating that, in the opinion of the Local Government Board, buildings constructed of ferro-concrete are likely to prove less durable than those of bricks and mortar, and that the Board are, accordingly, re-arranging the rates at which money is to be advanced for the erection of the first-named class of buildings, and requesting the opinion of the Royal Institute of British Architects thereon.

I am directed by my Council, who have adopted the report of the Science Standing Committee to whom the letter was referred, to write as follows :—

The First Commissioner of Works is no doubt aware that the extensive use of reinforced concrete and the exceedingly important part it plays in modern buildings led this Institute to appoint a Committee to consider and report on the subject, and to draw up regulations embodying the essential requirements for permanence and stability. The Institute invited the co-operation of other bodies in the work of investigation, and His Majesty's Admiralty, the War Office, the Institute of Builders, the District Surveyors' Association, and the Association of Municipal and County Engineers were also represented.

This Committee, of which Sir Henry Tanner, of His Majesty's Office of Works, was chairman, Col. Mayne R.E., of the War Office, and Prof. W. C. Unwin, F.R.S., vice-chairmen, after many meetings and discussions drew up a unanimous report setting forth the conditions under which reinforced concrete should be used, and found that under those conditions such work is trustworthy, and that decay of the metal is not to be feared.

This report was adopted at a general meeting of the Institute specially called to consider it. A copy is sent herewith.

It is impossible to place before the First Commissioner of Works any report of the discussions of that Committee, but some observations on the relative durability may be permitted.

All materials are subject to decay by the influence of the weather, time, and use, bricks and mortar being no exception to the rule.

Improperly made bricks or mortar perish rapidly, and brick buildings are specially subject to fracture from unequal settlement of foundations, or the movements of the soil due to the alternation of wet and dry seasons.

Few buildings are constructed wholly in bricks and mortar; and the wood and iron employed for the floors, lintels, beams, and story-posts, etc., by their decay also produce further destruction.

The dilapidations due to these causes are brought before the architect every time he makes a survey of an old building, and the desire to increase the strength and durability of his work has led during the last fifty years or so to the employment of iron and concrete for floors, roofs, lintels, and other parts on a constantly increasing scale.

The development of this type of construction from simple uses for parts of buildings to its employment to-day for complete structures of all sorts, road and railway bridges, sewers, water mains, reservoirs, jetties, piles, dock walls, coast protection, warehouses, and other buildings, etc., by Governments, municipalities, railway and dock companies, and private owners has been slowly built up step by step by practice and experience, aided in later years by scientific research, which research in foreign countries has been largely undertaken by the initiative and at the expense of the State.

Concrete (largely employed by the Romans for buildings still existing) is employed to this day in great works requiring undoubted durability. As an instance, we may cite the dams for the reservoirs in the Elan Valley recently constructed for the Birmingham Corporation, work on a large scale which no one would rate as less durable than brick or masonry or indeed otherwise than having an indefinite length of life.

The old concrete had lime as a matrix. Concretes employed for reinforced concrete work are now universally made with Portland cement, a material which is no longer manufactured in an empirical manner, but prepared with all the care which chemical science and highly skilled technical knowledge can bring to bear on it. Its strength and durability are therefore greater and more reliable than heretofore.

Unsuitable material or unskilled preparation in concrete, as in brick or mortar, will undoubtedly lead to failure, but it is to be assumed that proper supervision during construction is employed in concrete structures as in brick, or iron, or steel.

It is sometimes thought that the metal may perish, but all experience shows that concrete is the best preservative for iron or steel known to us. A bar of iron or steel slightly rusty embedded in properly made concrete may be taken out after some months, or after hundreds of years, brighter than when it was put in. Perhaps I may quote an instance—the experience of Mr. Somers Clarke, late Surveyor to St. Paul's Cathedral, who, being anxious as to the condition of the great chain tie which binds the dome at its base, caused an opening to be made in the concrete in which it has been embedded for over two hundred years, and found the iron bright and perfect, notwithstanding the fears which had naturally been felt because of the percolation of water from the gallery over it. This is but one of many examples, showing not only that metal reinforcements and concrete have been used by architects for many years back, but that their confidence in the durability of concrete and metal in combination is justified.

The many instances of the anchor chains of suspension bridges being embedded in concrete as a provision against their deterioration through the action of moisture may also be cited as showing the reliance placed on concrete by engineers for the protection of steel from corrosion.

It is sometimes thought by those who have not studied the question that the lightness of reinforced concrete work, upon which its economy depends, and the small covering of the bars are dangers which time has not yet proved unreal. As showing its durability even in trying cases we may instance the inquiry made by the city of Grenoble in 1901 into the condition of the reinforced concrete water-pipes laid down by the city in 1886. These pipes at the date of the inquiry had been in use for fifteen years. They are of 12 inches diameter, 1⅜ inch thick, with reinforcements of ¼-inch and 5/32-inch diameter. They have required no repair since made, have during that time resisted, and still resisting, without any fissuring or trace of oxidisation of the metal or flaw of any kind, a head of water of many feet.

There appears to us to be no more reason to doubt the durability of reinforced concrete in the walls, columns, floors, and roofs of buildings, and basement walls in damp situations, than in retaining walls, piled jetties, bridges, and other engineering structures.

There is also every reason to believe that it is as durable as brickwork or masonry for tanks, reservoirs, and similar structures, resisting the pressure of water under moderate heads, even if there be a slight sweating of water through the concrete, providing the metal is carefully embedded and thoroughly surrounded with concrete of a moderately wet consistency, and especially if the embedded metal has been washed over with a cement grout before being placed in it.

A still more severe test is afforded by works in sea water or works in tidal waters, and by bridges, the piers and abutments of which are exposed to abrasion by running waters. Constructions such as these are more in the province of the engineer, but their behaviour and the opinions practically shown by engineers in ever increasing the use of reinforced concrete are evidences of which we take account.

Though innumerable buildings in England have parts, such as floors, roofs, and lintels, in reinforced concrete, comparatively few have been executed entirely in it, one reason being the difficulty of securing a good artistic result, and another reason that our building by-laws, which fix the thicknesses of walls in nearly all cities, towns, and urban districts, prescribe certain minimum thicknesses for concrete walls, and no reduction is allowed even if strengthened by steel reinforcements. Accordingly there is no advantage gained by the use of reinforced concrete for walls except in the case of railway and dock companies and Government departments not under the control of local authorities. Such bodies have built and are building largely in reinforced concrete.

My Council would call attention to this strange anomaly of public authorities, which employ an economical method of construction and yet practically debar the private citizen from also using it under powers which are conferred for the protection of the public interest.

The accidents and failures which have occurred in reinforced concrete works have not arisen from a want of durability, but have almost invariably taken place when the centres are struck, as, contrary to experience in other materials, the strength of concrete increases with age. Improper materials and imperfect design which produce failure after completion would equally produce failures in other materials.

My Council are of the opinion that works in reinforced concrete which comply with the requirements laid down in the Report of the Committee appointed by this Institute are at least as durable as brick or stone buildings. They think that any re-arrangement of the rates, as suggested in the proposal of the Local Government Board, which would limit the period of loans for reinforced concrete work to less than the period for brickwork would be a mistake, resulting in this country being largely debarred from the advantages of modern and more economic methods of construction employed, not only by foreign countries, but by bodies not requiring the consent of that Board or free from the control of building by-laws.—I have the honour to be, Sir, your obedient servant,

W. J. LOCKE, *Secretary.*

The following acknowledgment has been received from the Hon. Sir Schomberg K. McDonnell, K.C.B., Secretary to H.M. Commissioners of Works and Public Buildings :—

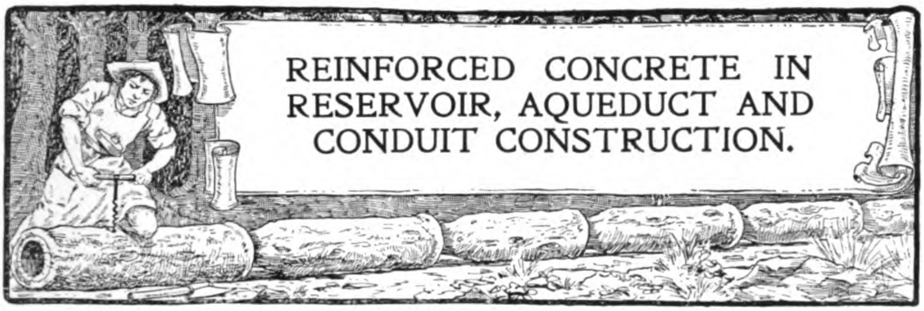
H.M. Office of Works, &c.,
Storey's Gate, S.W.,
11th December, 1907.

SIR,—I am directed by the First Commissioner of His Majesty's Works, &c., to acknowledge the receipt of your letter of the 9th instant, and I am to express to the Council of the Royal Institute of British Architects the thanks of Mr. Harcourt for the valuable report upon reinforced concrete construction with which they have been good enough to furnish him.—I am, Sir, your obedient servant,

SCHOMBERG K. McDONNELL.

The Secretary R.I.B.A.

NOTE.—The *Italics* are ours.



REINFORCED CONCRETE IN RESERVOIR, AQUEDUCT AND CONDUIT CONSTRUCTION.

PART I.

By E. R. MATTHEWS, A.M.Inst.C.E., F.R.S.E., F.G.S.,
Borough Engineer of Bridlington.

In our issue of November last, Vol. II., No. 5, we dealt with some examples of reinforced concrete reservoir construction, the author being the Borough Engineer of Bridlington, Mr. E. R. Matthews, F.R.S.Ed.

We are now presenting two further comprehensive articles on the subject of reservoirs and conduits by the same author, the first of which appears below.

There can be no doubt that the application of reinforced concrete for waterworks engineering, i.e., for reservoirs, water towers, tanks, conduits, and large pipes, has been found economical, and we should refer to some of our previous articles and notes as to the manner in which the material has been applied both at home and abroad.

One of our articles, which appeared in Vol. I., No. 3, Reinforced Concrete Water Mains, by Mr. R. H. Wyrill, Water Works Engineer of Swansea, we think merits special attention.—ED.

THE principal advantages of using reinforced concrete in the construction of reservoirs were clearly set forth by the author in No. 5, Vol. II. It is his intention now to give some particulars as to the cost of reservoirs constructed of this material, and also a number of typical examples of works of this class. He then intends to give some practical notes on reservoir construction, and finally to discuss the advantages of using reinforced concrete in the building of aqueducts and conduits.

REINFORCED CONCRETE RESERVOIRS.

(1). Cost of Reinforced Concrete Reservoirs.—The author finds in comparing the cost of reservoirs constructed in reinforced concrete, as compared with those of mass concrete or brickwork, that the saving generally runs about 15 per cent., and is sometimes even more; but this percentage will be due to a large extent to local conditions—that is to say, facility for getting concrete materials to the site. A case in point where a reservoir has to be constructed on a high hill, and there is no stone or sand in the immediate neighbourhood. In this case the saving will be fully 20 per cent., as we should save considerable money in buying and carting materials. Roughly speaking, it may be taken that the saving of reinforced concrete over ordinary concrete will, under ordinary conditions, be somewhere about 14 or 15 per cent.

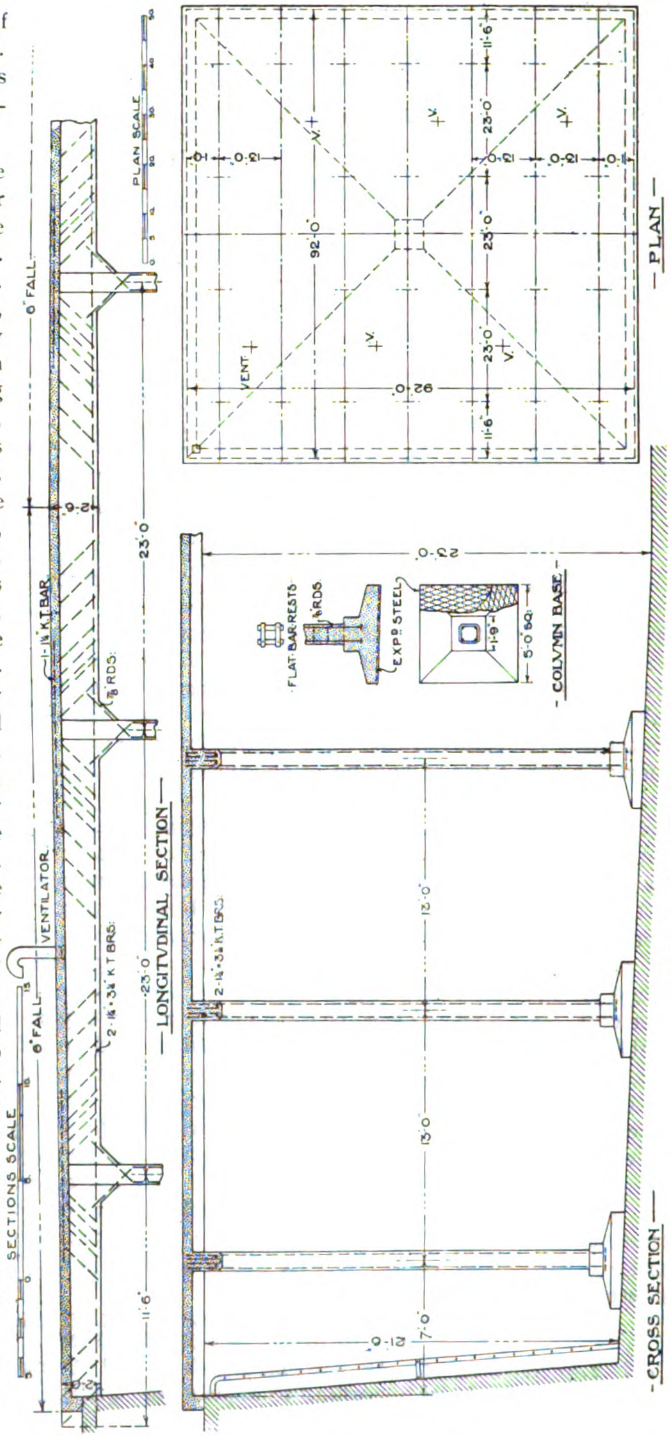
The cost of the Doscomb reservoir, described by the author in No. 5, Vol. II., will be about £575, whereas it would certainly have cost £650 to £700 if constructed in mass concrete. The cost of the Hill Side pressure maintaining tank, also described in the same issue, is about £340; if constructed in mass concrete it would have cost about £490. The cost of the Hill Brow level tank, also being constructed for the Petersfield Rural District Council, will be about £245, and if constructed in mass concrete it would have run to at least £300, as there is considerable carting in this last case.

TYPICAL EXAMPLES OF THE USE OF THIS MATERIAL IN RESERVOIR CONSTRUCTION.

(a) The covering-in of the Marypole Head Reservoir for the Exeter Corporation.—This is an interesting example of the application of reinforced concrete in the improvement of an existing reservoir. The work, which has only just been completed, consists of :—

(1) *Piers.* — The erection of a number of reinforced concrete piers. These are 12 in. by 12 in. with 1½ in. chamfered corners, and are reinforced by four steel rods ⅞ in diameter, one being placed at each corner, and outside these rods is placed 3-16ths in. diameter hooping. The bases of the piers, which are 5 ft. square, and vary in thickness from 6 in. to 12 in., and which rest on the floor of the old reservoir are reinforced by No. 10 expanded metal, 3 in. mesh. Upon this foundation, footings, 1 ft. 9 in. by 1 ft. 9 in., rest; these are 9 in. in thickness. The vertical rods of the piers rest on flat bar rests, 1 ft. 3 in. by 1 ft. 3 in., formed of 3 in. by ¼ in. metal. The piers are spaced 13 ft. apart, centre to centre, in one direction, and 23 ft. in the opposite direction, the outer row of piers being placed 7 ft. and 11 ft. 6 in. from the walls of reservoir, and the height from floor of reservoir to underside of roof is 21 ft. 6 in.

(2) *Roof.* — The reservoir is 92 ft.



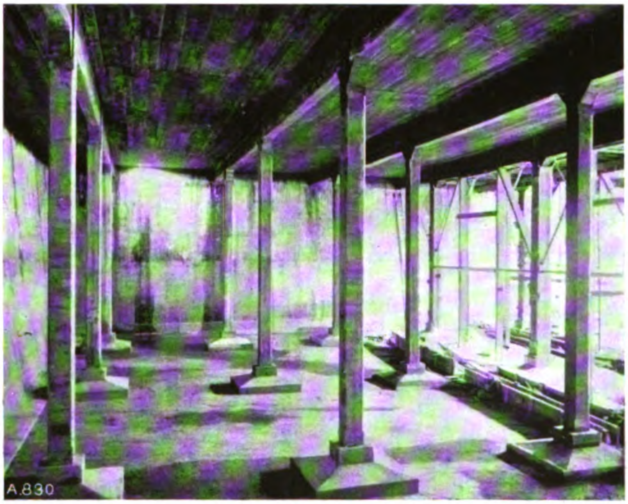
Marypole Head Reservoir for the Exeter Corporation.

square, and the roof is formed in the shape of an umbrella, with a fall of 6 in. in all directions from the centre. The covering is 5½ in. in thickness, and is reinforced by No. 10 expanded metal, 1¼ in. bars. The beams supporting this roof are 10 in. in thickness, and 1 ft. 6 in. to 2 ft. in depth, and are reinforced by the insertion of 2 in. by 3¼ in. K.T. bars (alternating type) and ⅞ in. diameter rods. An 18 in. by 18 in. C. iron inspection chamber cover and frame is inserted in one corner of the roof.

This excellent piece of work was designed by Mr. Thos. Moulding, A.M.I.C.E., the city engineer of Exeter, the work being executed by the New Expanded Metal Company, Ltd.

(b) ***Cranleigh Reservoir.***— At Cranleigh, in Surrey, Mr. F. S. Courtney, M.Inst.C.E., of Westminster, has recently constructed a reservoir of over 500,000 gallons capacity, in which the whole structure is of concrete reinforced with expanded steel, attached to a light framework of rolled steel girders. The accompanying drawings show the general design of the structure, and the photographs illustrate the method of construction.

The floor is constructed of steel joists, connected longitudinally by fishplates and laterally by a series of round steel bars. Sheets of expanded steel are laid so that the ends of the sheets rest on the lower flanges of the joists. The columns supporting the roof are attached to the floor joists by fishplates of special form. The roof girders of somewhat lighter section than those used in the floor are laid parallel to the latter, and are connected laterally by light steel bars.

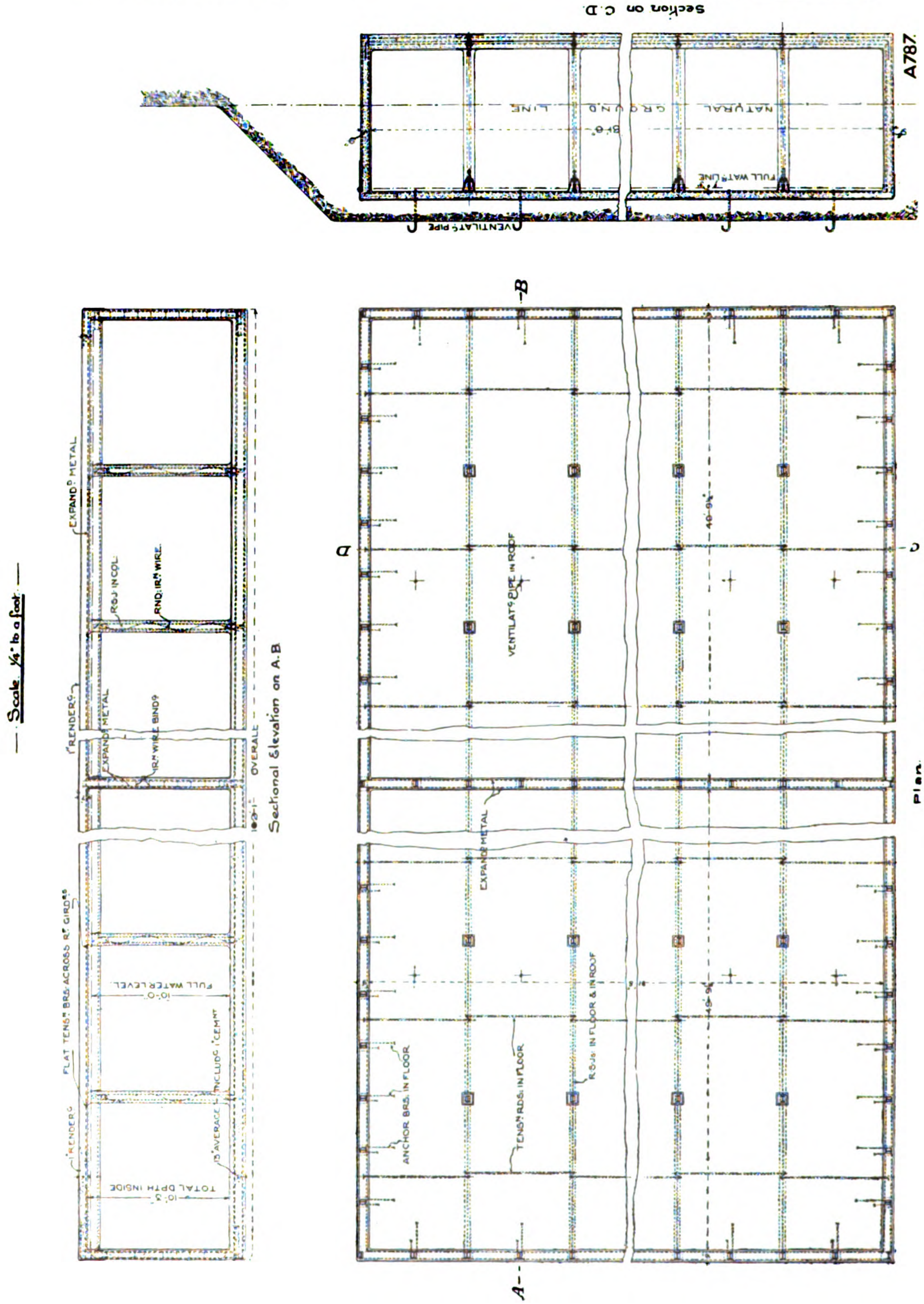


MARYPOLE HEAD RESERVOIR
(Interior view.)

The whole of the steel framework was erected before commencing the concrete work, and, as it formed an independent structure, the centreing for the walls and roof could be used over and over again, as each section of the concreting was completed. The walls are reinforced with expanded steel, both on the outside and inside, a somewhat heavier section of the material being laid in one layer only in the roof. The concrete is of the following average thickness:— Floor, 12 in.; walls, 8 in.; roof, 6 in.

Some of these dimensions may be considered excessive by the apostles of reinforced concrete, but it was considered wiser to provide an ample thickness of protection to the metal rather than save a few yards of concrete.

The whole of the steelwork in the finished structure is embedded in concrete, the surface of which is rendered with a mixture of equal proportions of cement and sharp sand. The chief dimensions of the reservoir are:—Length, 102 ft.; width, 83 ft. 6in.; depth, 11 ft. 4 in. The reservoir is divided into two compartments by a partition wall extending from floor to ceiling, of the same section as the outer walls.



CRANLEIGH RESERVOIR, SURREY.

When finished the reservoir was tested by filling one compartment up to top water-line, and leaving the other compartment empty. In this way it stood for five weeks, at the end of which time the face of the 8 in. partition wall in the empty compartment did not show the slightest trace of moisture, being as dry as it was before the other compartment was filled. Each compartment was fitted with its own supply service, wash-out and overflow pipes. On the bodies of the special pipes passing through the walls, flanges were cast, and care was taken that these should be soundly bedded in the concrete, which, immediately round the pipe, was made of a somewhat finer gauge than the average. When finished, the roof was covered with soil to the depth of 18 in., and the sides were banked up with earth slopes of 1½ in. to 1 in.

In comparing the cost of this work with others, local conditions have to be taken into account, as well as the time of year at which the work was carried out. The soil at the site of the reservoir was of a wet slippery clay in winter, baking hard or cracking in the summer. The finished floor of the reservoir was 4 ft. below, and the top water-line 6 ft. above ground level.

It was found advisable to provide drainage for the underside of the floor of the reservoir; a thickness of 12 in. of broken stone and rubble, with longitudinal drains laid through same, was provided, the surface was levelled off, and on it the longitudinal floor joists and concrete were placed. There was no local gravel or sand available for the concrete, all of which had to be obtained from some distance, entailing railway carriage with cartage at either end.

Cost.—The total cost of the completed work came out at £4 2s. per 1,000 gallons, a price considerably lower than that of brick or plain concrete reservoirs constructed by Mr. Courtney in the immediate neighbourhood upon competitive tenders. An alternative estimate submitted for a plain concrete reservoir was just 30 per cent. more than the above cost. The concrete consisted of five parts aggregate to one part of Portland cement, the coarsest stones having to pass a ¾ in. ring.

(c) Ipswich Water.—This reservoir is of concrete throughout, and measures, roughly, 300 ft. by 200 ft. by 15 ft. deep. The cover, carried on rolled steel joists, resting on cast-iron columns, is 6 in. in thickness, reinforced with 3 in. mesh expanded steel near its underside. The rolled steel joists are at 8 ft. centres, without secondary joists.

The reservoir was designed and constructed by the late Mr. H. Roberts. It has a capacity of 4½ million gallons, and the author is informed by the present engineer and manager, Mr. C. W. S. Oldham, that the roof has given no trouble, but is perfectly watertight, although it has been completed just four years. A few small initial cracks appeared in the concrete (concrete four to one); these were filled with liquid bitumen.

(d) West Kirby New Service Reservoir.—No. 2 new service reservoir at the works of the Hoylake and West Kirby Gas and Water Company, Cheshire, was built in 1903, it having been designed by Mr. Alfred J. Jenkins, A.M.I.C.E., the engineer to the company.

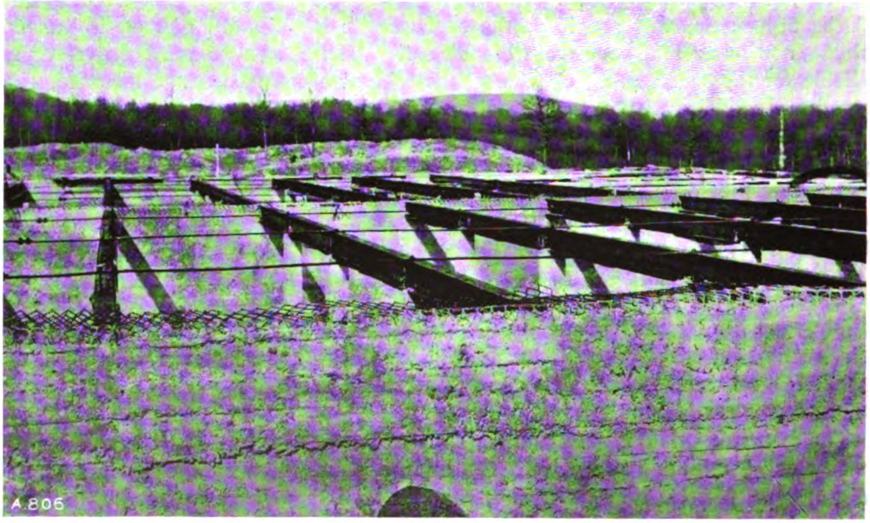
The reservoir is 160 ft. by 120 ft., inside dimensions, by 30 ft. deep. The roof is carried on mild steel stanchions, which are incased in ⅜ in. mesh expanded metal lathing, with concrete backing, covered with cement mortar. It is built on the channel-arch system, with rolled steel joist mains, the steel-work in the roof being incased in the same way as the stanchions. Three-inch mesh expanded metal was used in the reinforcement of the roof, which is 5 in. in thickness. The roof has a fall of 12 in. from the centre to the surrounding walls, and is cambered. The channels are 6 1-16 in. by 2⅛ in. in section, with spans of 16 ft. 6 in., and are at 7 ft. 6 in. centres. The work was executed by the New Expanded Metal Co., Ltd.

(3) POINTS TO BE OBSERVED IN CONSTRUCTING RESERVOIRS IN REINFORCED CONCRETE.

(1). ***Concrete.*** — In America, what is known as "wet" concrete is used in the construction of the floors, walls, and roofs of reservoirs. This needs little or no ramming, as it consolidates by its own settlement. But the British practice is, in the author's opinion, preferable—namely, to put in, moderately, wet concrete in layers, and to ram each layer. This makes a solid mass, which cannot be obtained when the former method is adopted. The author's opinion in this matter would seem to be confirmed by experiments made by Mr. Geo. W. Rafter, M.Am.Soc.C.E., for the State Engineers' Office of New York, which showed that the compressive strengths of concrete, mixed of moderately dry, plastic, and wet mixtures, were as follows :—

Dry Mixture	156 blocks ...	2470 lbs. per sq. in.
Plastic Mixture	144 blocks ...	2294 ,, ,, ,, ,,
Wet Mixture	148 blocks ...	2180 ,, ,, ,, ,,

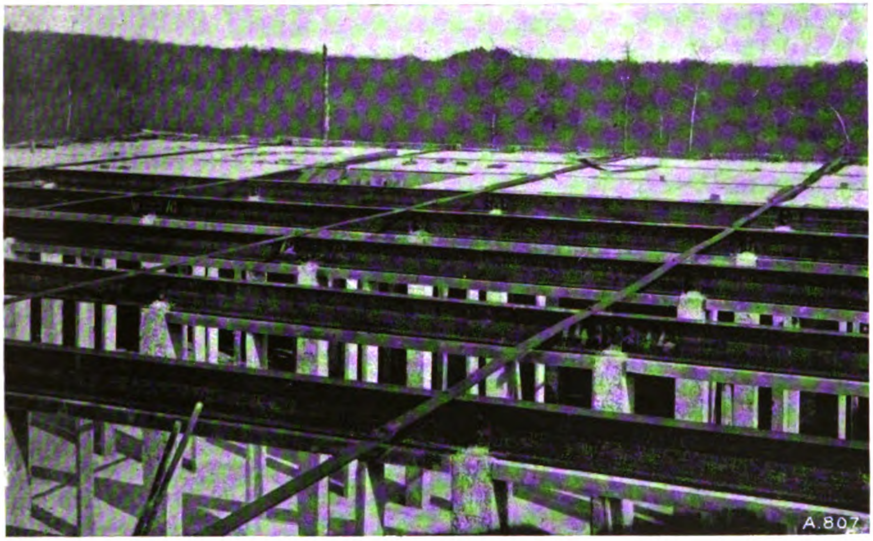
The blocks tested were 12 in. cubes, and these were 18 to 24 months old.

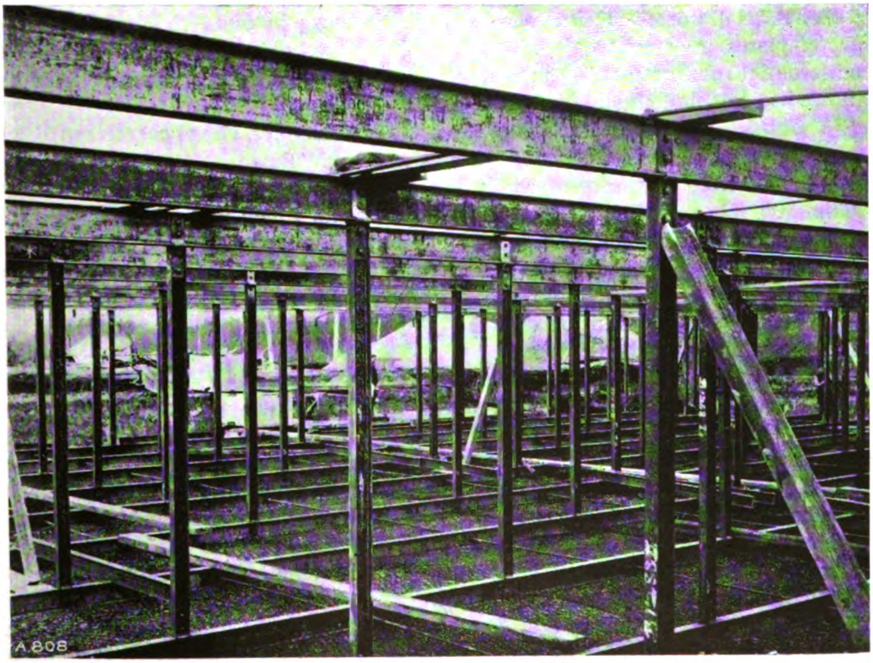


CRANLEIGH RESERVOIR, SURREY.
(Showing "Expanded Metal" reinforcement.)

(2). ***Roofs.***—Most of the covered reservoirs in America have roofs constructed on the groined-arch principle, while a few are of the ribbed-arch construction. A good example of a roof of this type may be seen in the reservoir at Rockford, Illinois, U.S.A. The ribs in this case are spaced 7 ft. apart, and increase in depth from crown to haunch. Each is reinforced by an introdasal channel, laid face downward. The arch ring proper is 2 in. in thickness, reinforced by expanded metal placed near its soffit. The concrete used in this roof was one part Portland cement, two parts sand, and five parts fine gravel, the soffits being plastered with Portland cement mortar. This reservoir is rectangular, and is 66 ft. by 156 ft. in plan. These methods of roof construction are more expensive than the flat roof of the British design, for they take more material, cost more for centreing and timbering, and take longer to construct. The roof of the Rockford reservoir cost £408 6s. 8d.

(3). Piers.—The reinforced concrete piers of British reservoirs are usually rectangular in plan, the reinforcement consisting of four steel rods, one placed at each corner of the pier, and circumferential reinforcement, in the shape of wire wrapped around these rods.





CRANLEIGH RESERVOIR, SURREY.
(General views.)

Circular piers, however, have recently been introduced in American practice, and the author very much favours these, for the following reasons :—

(1) There is a saving of material over square piers.
(2) They occupy less space.
(3) They can be constructed at the same price as rectangular piers.

(4). ***System of Reinforcement.***—When comparing the merits of the various systems of reinforced concrete construction now available, too much stress is often laid on the saving in quantity of actual concrete in the finished structure. The amount of centreing required, and the possibility of the timber being available for use in other works in the immediate neighbourhood, and also the amount of skilled supervision required during the placing of the armouring, are most important considerations when deciding upon the suitability of a particular method of construction.

Covered reservoirs for water supplies are usually situated at a high elevation, and at some distance from a town, where the considerations above mentioned are of great importance.

(5). ***Forms and Centres.***—In constructing the forms, centres, and column boxes, it should be remembered that the cost of these is a large item of the total cost of the work, and so, with ingenuity and forethought, this work should be so arranged that the repeated use is made of each form, centre, or box. They should be formed of well-seasoned timber. It should also be remembered that wedges and wire ties are most convenient for tightening up false work, and these should be made free use of, nails being used as little as possible.

(6). ***Arrangement of steel in columns.***—This requires great care. The vertical bars should be uniformly 1½ in. to 2 in. from the box; in order to space these bars, wood templates may be employed. Special care should be taken in placing the circumferential reinforcement around these bars; if this consists of wire, it should not be allowed to sag, but should be drawn tight.

(7). ***Sand.***—In the construction of the roofs of reservoirs, clean, coarse sand should be used, but fine sand is preferable for the walls and floors. The sand should, of course, be free from any trace of chalk, loam, clay, or earthy matter.

The author has proved, by a series of experiments which he has carried out, that concrete mixed with coarse sand is stronger than if mixed with fine, but the latter is less permeable. His conclusions in this respect seem to be verified by the elaborate tests of Mr. R. Feret, of the Boulogne Laboratory, and which extended over five years. Mr. Feret came to the conclusion that the minimum permeability occurred where there were as many fine grains as coarse.

A series of experiments, carried out by Mr. A. W. Hyde and Mr. W. J. Smith, on the permeability of concrete showed that mortars made with fine sand are less permeable than those mixed with coarse sand, and also that the permeability decreased as the proportion of cement was increased.

(8). ***Aggregate.***—In the construction of reservoir walls in America the concrete used sometimes consists of about 40 per cent. of boulders. No doubt a saving of cement occurs where this method is adopted, but the author considers the practice undesirable, for the wall cannot be so strong as if made of a homogeneous mass throughout, and a leakage is more likely to occur. The aggregate should consist of the hardest stone obtainable in the district. Porous substances, such as cinder, slag, and coke breeze, should be avoided. Rounded stones are inferior, in the author's opinion, to broken stone, and no stone should be of such a size that it will not pass through a 1 in. ring.

(9). ***Portland Cement.***—The quality of this is of the greatest importance. It should pass the various tests set out in the British Standard Cement Specification.

(10). Proportion of parts.—All concrete for columns should be in the following proportions:—One part Portland cement, one and a half parts sharp sand, and three parts broken stone or gravel; and for the floors, walls, and roofs of reservoirs—one part Portland cement, two parts sand, and four parts broken stone or gravel.

(11). Concrete Mixing.—The manner in which this is executed is of the greatest importance. The American principle of mixing all concrete by machine, is, in the author's opinion, the best, as when mixed by hand it cannot be turned over in a uniform manner. Great care, however, should be exercised in seeing that the machine used is a thoroughly reliable one. All concrete should be well rammed.

(12). Placing Concrete.— Forms should be oiled—or, better still, covered with vaseline—so as to facilitate their removal.

When concreting is once commenced it should, in the case of columns, be carried on, if possible, rigorously until completion. If this is impossible, the surface of the unfinished column should be left rough, and, before any further concrete is added, a coating of one-to-one cement mortar should be applied.

There are two methods of constructing columns—one is to pour the concrete in from the top of the form; if the column is greater in height than 12 ft., the concrete should not be poured in from the top, but about one-half in such case from an intermediate pocket, and well rammed with long-handled rammers. The other method is to make the column moulds with one side open, to board up the open side in stages, and to fill the concrete in in layers of about 9 in. in depth, and well ram each layer. The author prefers this latter method, although the former is generally adopted in America.

(13). Removal of Forms and Centres.—Great care should be exercised in this. No jarring of the structure or allowing planks to fall should occur. The practice of ramming down the posts and letting everything crash to the floor should not be tolerated.

(14). Cement finish.—If, say, 1 in. of cement rendering is to be put on, this should be one to one, and should be done at the time of laying the concrete, otherwise it will not properly adhere. Neat cement is often used to point up the concrete, no rendering being applied. The author prefers this latter method to the former.

(15). Steel.—Mild steel, produced by the basic open-hearth process, with a tensile strength of about 30 tons per square inch, and an elongation of 20 per cent. in a 8 in. length is generally considered the most satisfactory.

(16). Preservation of steel in concrete.—Although occasionally an instance is cited to show that steel embedded in concrete will corrode, yet the bulk of the evidence to be produced clearly demonstrates the fact that this is not so. A score of exhaustive experiments also verify that decision. Mr. J. S. E. de Vesian, M.Inst.C.E., in an excellent paper on "Reinforced Concrete," recently read before the Civil and Mechanical Engineers' Society, London, says:—"Sewer pipes with steel reinforcements have been lately replaced on the Continent after forty years' use, and the steel was found to be in good condition." He also quotes another case—namely, at Southampton, where a number of reinforced concrete piles, which had been in tidal waters for eight years, were shortened, the reinforcement being made bare, and this showed that, where there was even only a ½ in. covering the steel was in good preservation. The author had occasion, about two years ago, to repair a concrete *in situ* sea-wall at Bridlington, which had been constructed 25 years previously, and which was reinforced by iron chains. In carrying out the repairs, it was necessary that these chains should be made bare in several places, and they were found to be in as good condition as when they were first inserted in the wall, no corrosion whatever having taken place. These three examples, the author considers, are sufficient to warrant us taking it for granted that, where the bars are free from rust when inserted and are properly embedded in the concrete, corrosion of the metal cannot take place.

In the United States and France, however, as a further precaution against corrosion, cement washes have, in many instances, been applied to the metal before its insertion. This method has been strongly recommended by Professor Chas. L. Norton, of the Massachusetts Institute of Technology, of Boston, the results of whose experiments have led him to the following conclusion :—"That neat Portland cement, even in thin layers, is an effective preventative of rusting." Mr. Breuillie, of France, has shown, by a series of experiments which he has made, that, so far from the metal becoming corroded by being inserted into the concrete, the reverse is the case, and that, by inserting metal which is already corroded into concrete, the corrosion is removed.

The few instances of corrosion to which the author's attention has been drawn have occurred where voids or cracks in the concrete have been met with, and this clearly shows the necessity of the greatest care being taken in placing the concrete in the forms and thoroughly ramming. As fine cracks, however, especially in culvert work, are unavoidable, the author considers that it is advisable to give the metal a coat of cement wash before inserting it, especially seeing that the cost of same is so small.

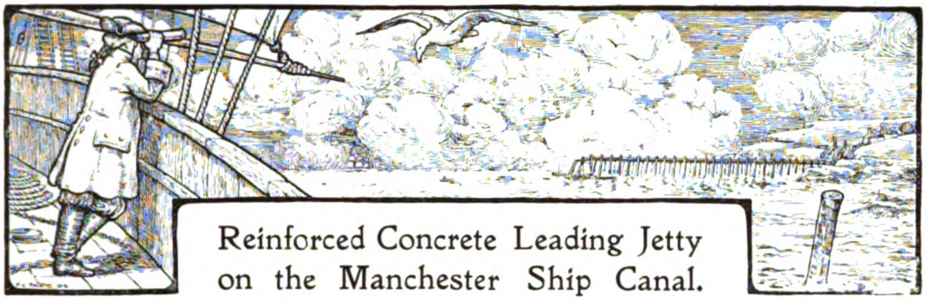
(17). Methods of calculation.—This is a very difficult matter, as there are so many theories in existence. The "limit of stress," as given in the Building Regulations of the City of Buffalo (1906), is as follows :—Tensile stress in steel, 16,000 lbs. per square inch; shearing stress in steel, 10,000 lbs. per square inch; concrete in compression, 500 lbs. per square inch; concrete in shear, 50 lbs. per square inch.

The foregoing notes, in the author's opinion, represent some of the principal points that require attention in order to ensure efficient work when constructing reservoirs and similar structures of reinforced concrete.

The greatest care must always be exercised in placing the concrete and in seeing that all reinforcement is properly embedded; no slip-shod methods, as are sometimes unfortunately met with when workmen are dealing with mass concrete, should be tolerated by the engineer, clerk of works, or foreman, when reinforced concrete is the material employed.

The author wishes to express his indebtedness to Mr. F. S. Courtney, M.Inst.C.E., for the privilege of reproducing the drawings and photos of the Cranleigh reservoir, and for much valuable information respecting this reservoir; to Mr. Harry W. Taylor, A.M.I.C.E., of Newcastle, for kindly supplying him with information respecting the cost of the Doscomb and Hillside Reservoirs; to Mr. Thos. Moulding, A.M.Inst.C.E., the city engineer of Exeter, for the drawings and other useful information concerning the Marypole Head reservoir; to Mr. C. W. S. Oldham, waterworks engineer of Ipswich, for much useful information respecting the new covered reservoir at Ipswich; and to Mr. Alfred J. Jenkins, A.M.Inst.C.E., for particulars respecting the West Kirby reservoir, as also to the New Expanded Metal Co., Ltd., for photographs.

(To be continued.)



Reinforced Concrete Leading Jetty on the Manchester Ship Canal.

Designed by W. H. HUNTER, M.Inst.C.E. (Chief Engineer).

The Manchester Ship Canal Company and their Chief Engineer, Mr. W. H. Hunter, M.Inst.C.E., M.Am.Soc.C.E., enjoy the reputation of having been pioneers in this country in the application of reinforced concrete on a large scale, and the Manchester warehouses are characteristic examples of their enterprise and technical acumen.

The work dealt with in these pages, however, if not great, has the merit of being quite unique in the annals of reinforced concrete construction, and shows to what uses this material can be put by those who thoroughly realise its advantages.—ED.

THE new leading jetty of the Manchester Ship Canal, which is being constructed at the Irlam Lock, will be a notable example of reinforced concrete construction.

The circumstances necessitate work of great strength with the least possible hindrance to the traffic of the canal, and the manner in which the difficulties of construction have been overcome explain themselves clearly on reference to the illustrations presented, which not only show the leading jetty, but give details of the individual caissons used.

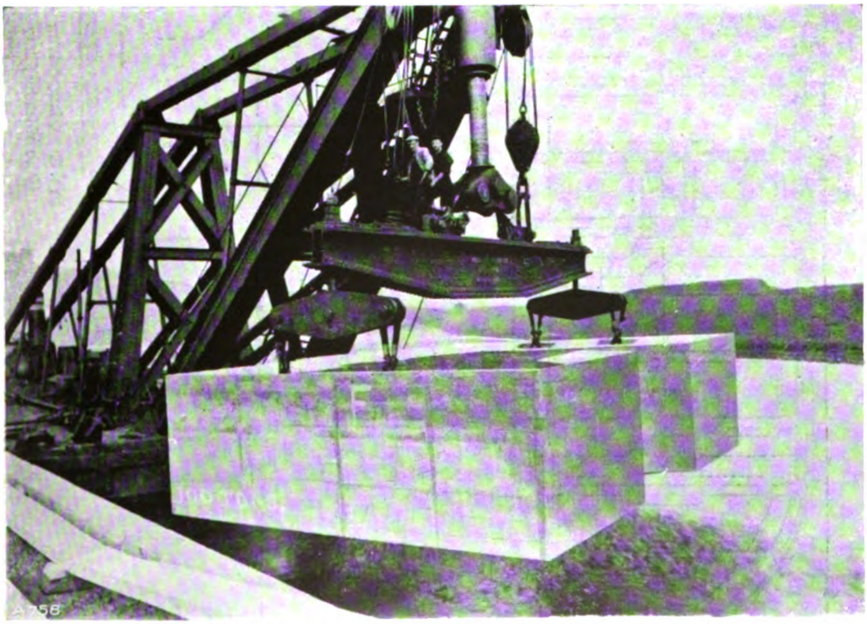


FIG. 1. REINFORCED CONCRETE CAISSONS ON THE MANCHESTER SHIP CANAL.
(Caissons being slung.)

The principal feature of the leading jetty is the system of construction adopted. It is being constructed in the form of a number of reinforced concrete caissons dropped into position on to a flat bottom, and held in position by strong reinforced concrete piles.

The drawings may be said to explain themselves, as they are taken from the

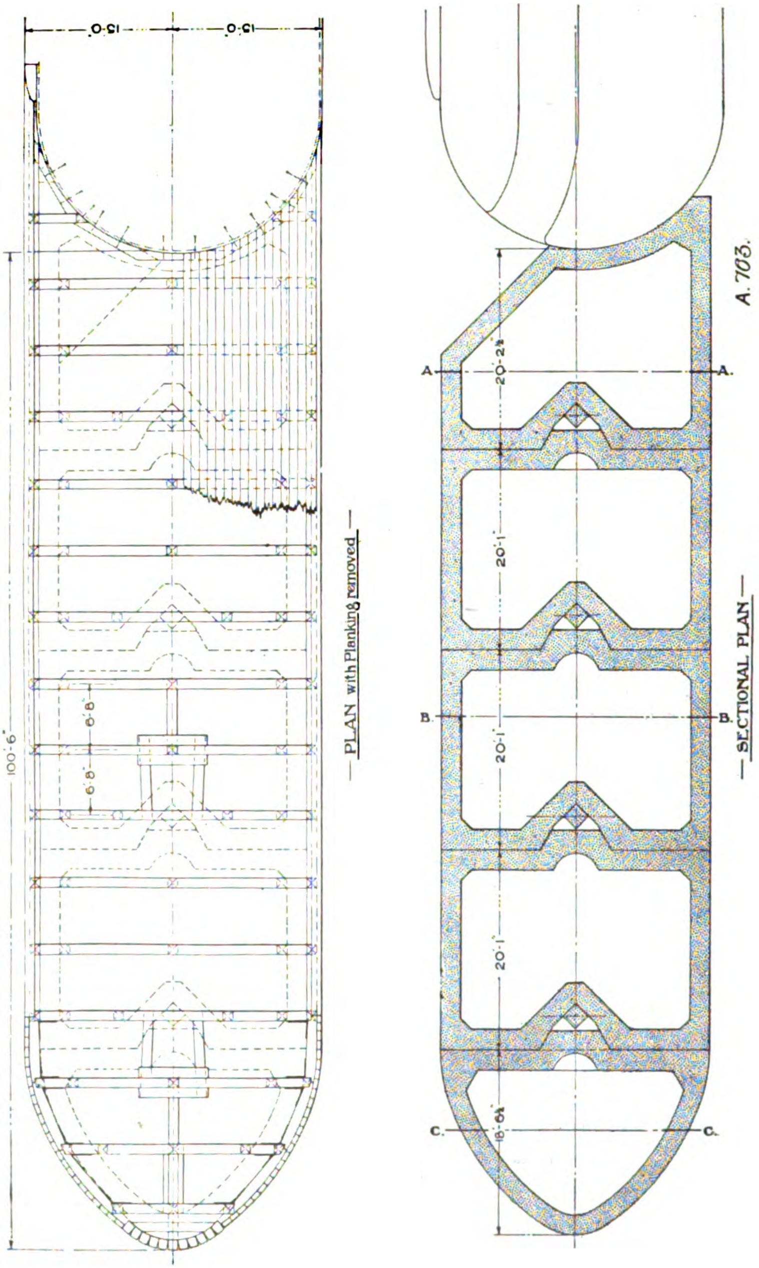


FIG. 2. MANCHESTER SHIP CANAL.
(Plan of leading jetty and caissons.)

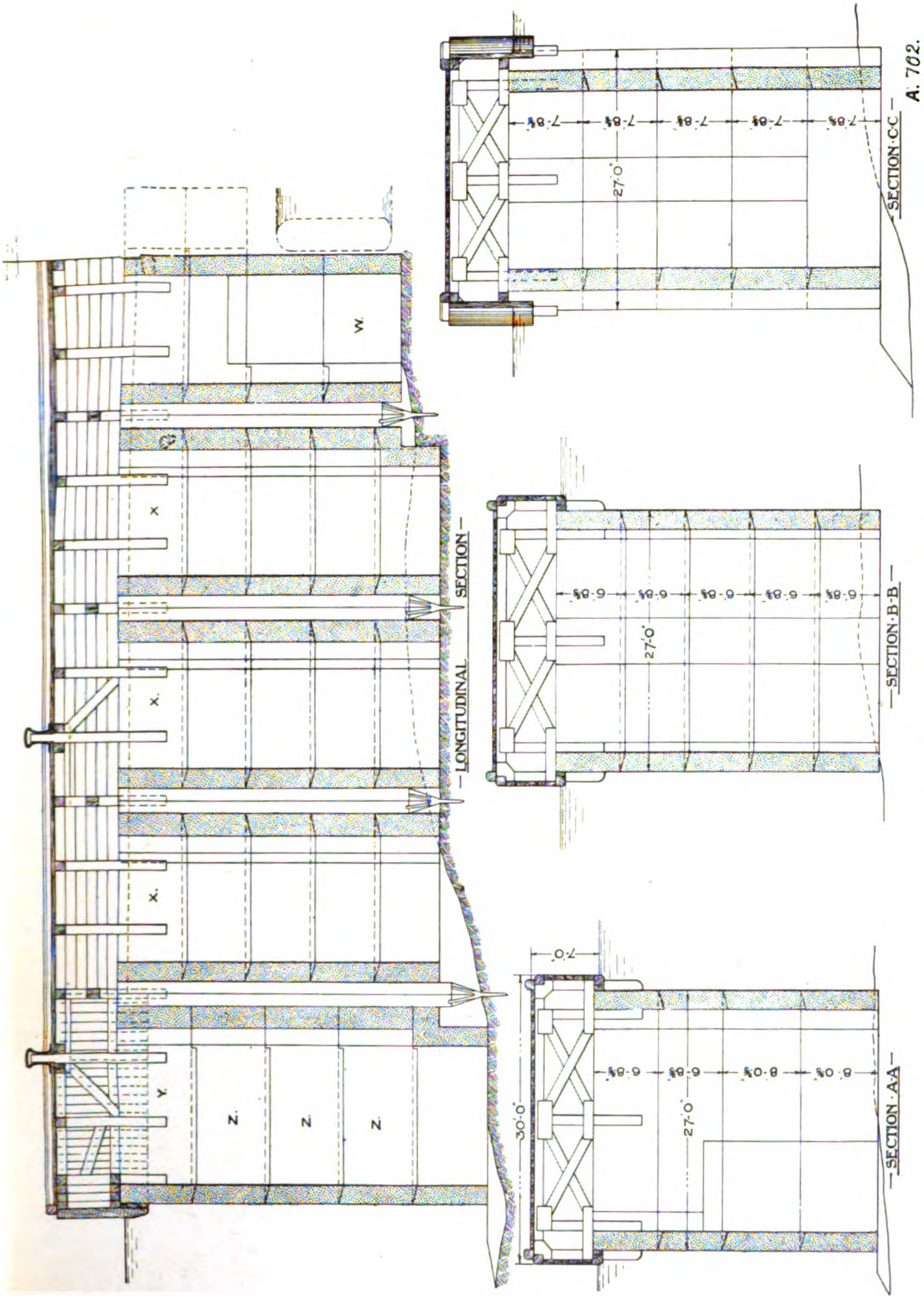


FIG. 3. MANCHESTER SHIP CANAL.
(Sections of leading jetty and caissons.)

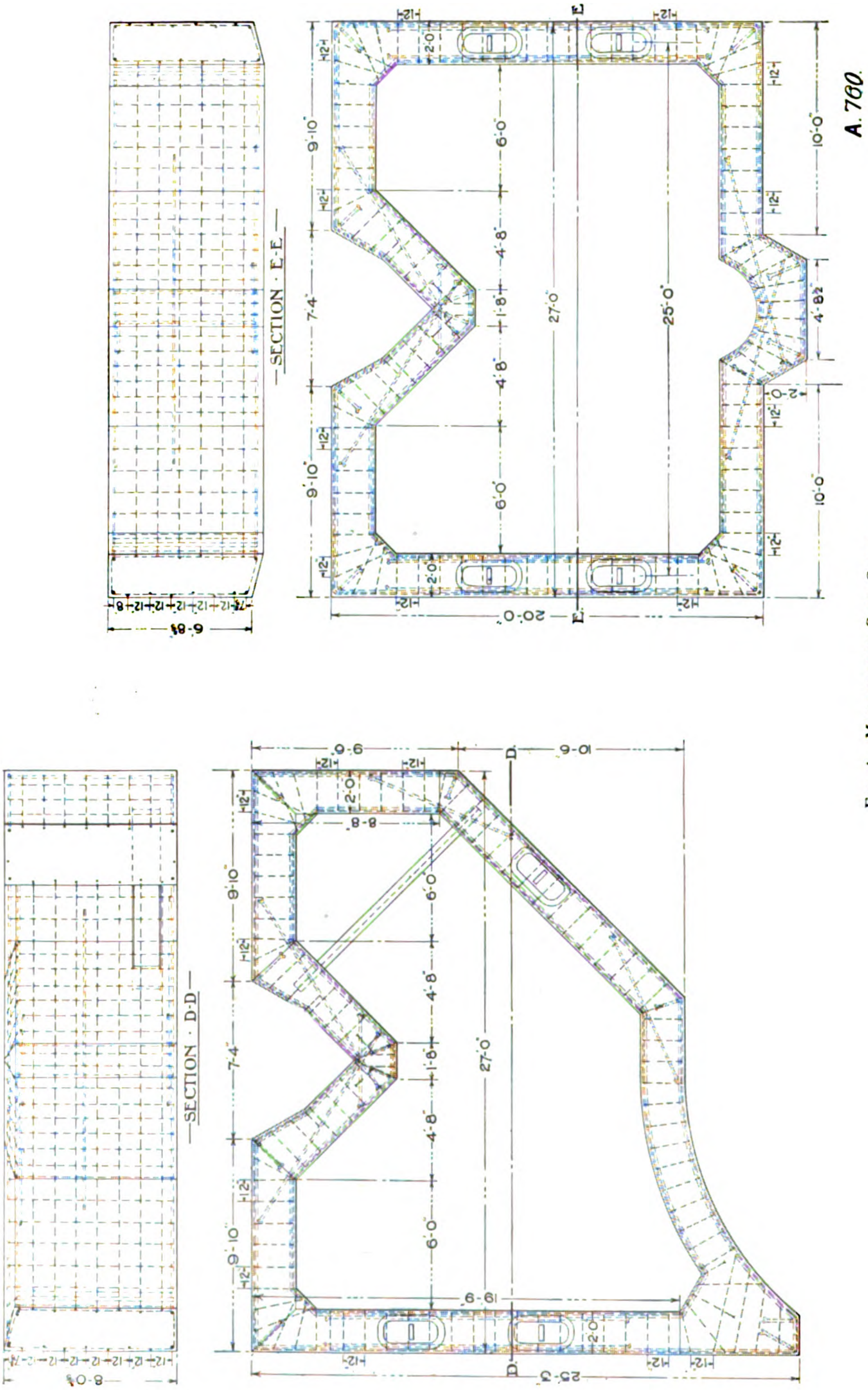


FIG. 4. MANCHESTER SHIP CANAL.
(Details of caissons.)

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CONCRETE & CONSTRUCTIONAL ENGINEERING

ANNOUNCEMENT.

THIS journal was founded with the object of meeting the demand for reliable technical and economic information regarding concrete, reinforced concrete, and constructional engineering generally.

The uses of concrete and steel are at present being accorded the closest possible attention throughout the world.

This journal continues to present a reliable digest of the world's latest information on concrete and constructional engineering as applicable to British and Colonial readers. It is intended to serve as a guide to what is being done at home and abroad, and will also serve as the medium for the expression of thought and opinion affected, presented by the ablest exponents on all questions connected with concrete and constructional engineering.

Nearing the third year, the reception of the first two volumes has been most encouraging, and the subscription list is not only extensive, but includes the names of prominent leaders of the professions concerned.

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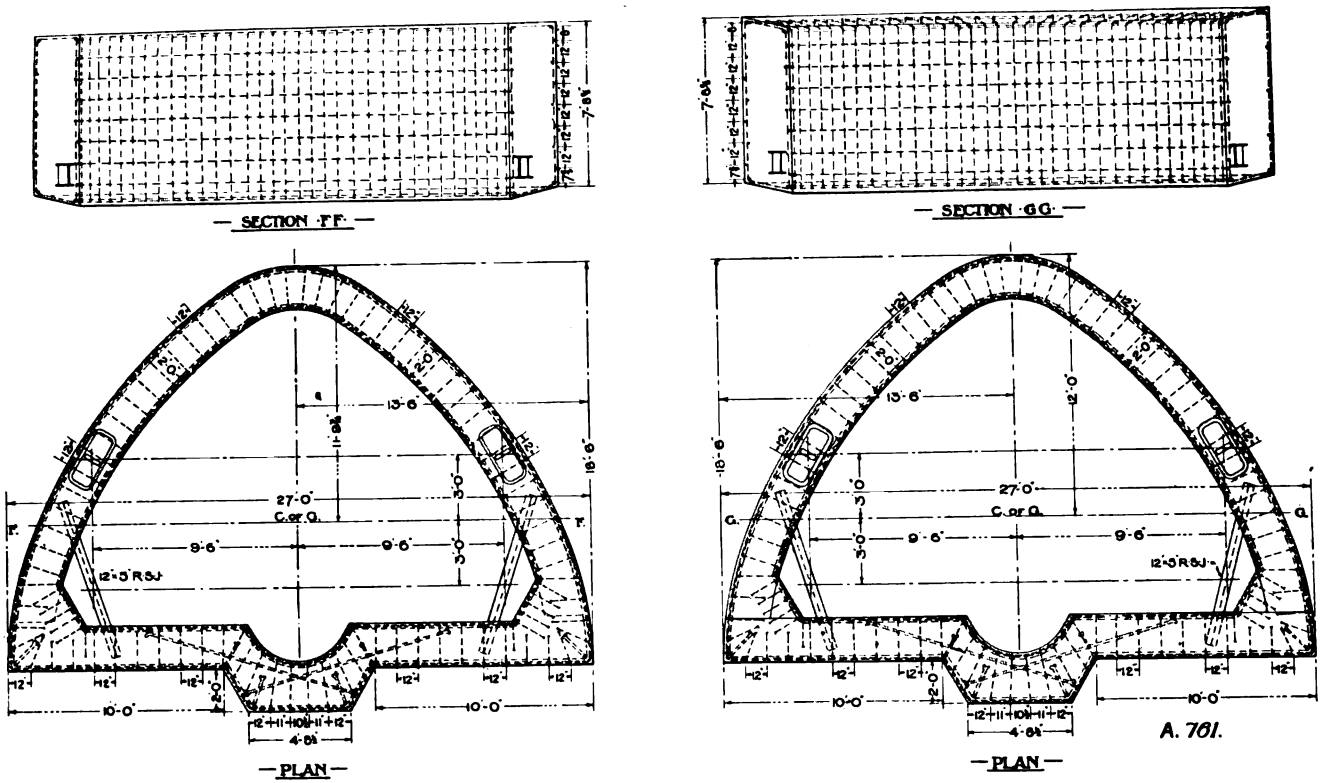


Fig. 5. Manchester Ship Canal.

(Details of Caissons)

actual working drawings with all dimensions on so as to be useful for practical reference. The photographs indicate how the caissons are swung in pairs, *Fig.* 1, while *Fig.* 6 shows how they are seasoned under water whilst awaiting application.

The following particulars as to aggregates used may be of some interest:

The aggregate was Pirl ballast with the gravel screened from the sand, the former being broken where necessary to pass through a 1 in. mesh.

When the quantity of sand obtained by the process of screening was in excess of the gravel broken, Penmaenmawr stone was used to make up the deficiency in the gravel. A good Portland cement was used.

The concrete was mixed in the following proportions: gravel, 27 cu. ft.; sand, 13½ cu. ft.; cement, 6 cwts.

The concrete was then deposited in layers of a thickness not less than 4 in. and not more than 6 in., each layer being carefully rammed into place.

Where the caisson was not finished at one operation the joint in the work was always left horizontal, and on resuming work the surface of the concrete already deposited was carefully brushed, washed, and coated with cement grout before concreting was resumed.

Another point that may be of some interest is to note the weight of the caissons, the positions of which will be found marked on the drawing.

The calculated weights are as follows:

	TONS IN AIR.		TONS IN AIR.
Caisson A	100·32	Caisson F	73·45
B	107·02	W	101·19
C	103·60	X	88·64
D	85·30	Y	77·25
E	81·95	Z	75·83

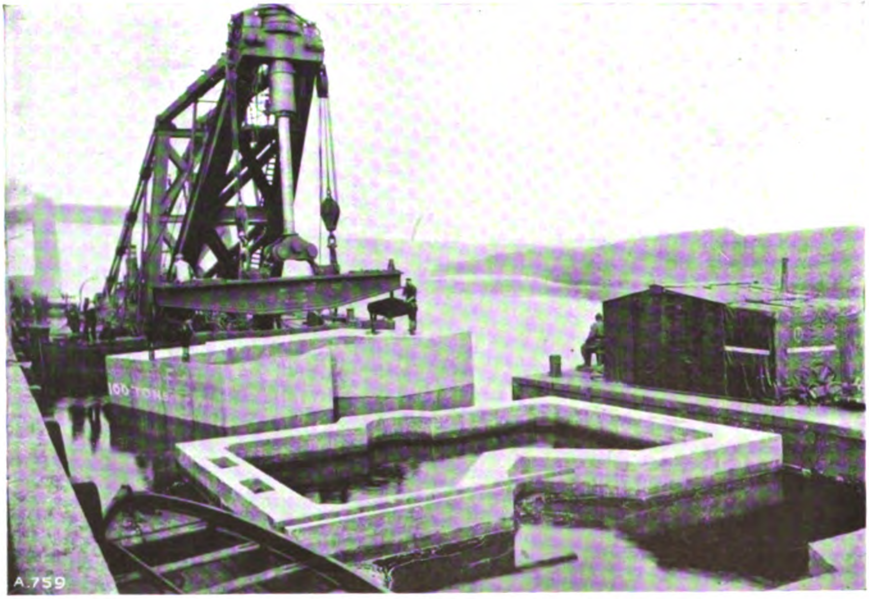


Fig. 6. Caissons on Manchester Ship Canal.
(Being seasoned before use.)

NOTES ON THE USE OF CONCRETE IN MINES

By W. R. CRANE, Assistant Professor of Mining, Columbia University, N.Y.

Of the many instances in which the use of concrete and reinforced concrete has been neglected in this country, as also in our Colonies, none are more remarkable than those connected with mining.

There are innumerable uses for concrete and reinforced concrete in Mines. Timber is getting more and more expensive, deteriorates very rapidly in some mines, requires constant repair and reinstatement, and is dangerous to a degree in mines where there is a fire hazard.

It is our intention to call attention to examples where concrete and reinforced concrete have been used in mines, and present them as a guide to engineers interested in mining work. In this case our examples are from the United States, and in our next issue we shall present some from the Continent. We trust these instances will lead to a better appreciation of the utility of concrete for mine work, and also tend to lessen the loss of life with which mining is so unfortunately associated.—ED.

CONCRETE is very favourably looked upon and is receiving extended application in practically every phase of American mining practice.

Reasons for Use of Concrete.—The increasing cost of timber and the difficulty experienced in securing a proper quality, which, combined with its comparatively short life under existing conditions, are among the most important factors influencing its discontinuance in mining practice.

2. Stone, brick, and cement are, under our improved transportation facilities, available at moderate cost in practically all districts. However, stone and brick have not met with much favour in American mining practice, due probably to their lack of imperviousness. Further, the cost of placing brick or stone, especially in shafts, is usually high owing to the adverse conditions encountered and the high price of skilled labour.

3. Concrete has the advantage over stone and brick work in many cases, in that it can be more readily placed, and as fewer skilled labourers are required the first cost is often considerably less. However, as compared with timber, it takes about three times as long to place concrete, and from actual experience it has been shown that concrete exceeds timber work in first cost from 25 to 45 per cent., the variation depending largely upon the shape of the shaft.

4. When once constructed a concrete lining is practically indestructible throughout the ordinary life of a mine, and as no repairs are necessary it has a decided advantage over timber, as there are no delays with their consequent loss of output and extra expense of maintenance.

5. Another factor is the great strength of linings made of concrete, as compared with those of timber, this applying even when of the same shape. Further, concrete can be employed where stone and brick are not applicable and to greater advantage than timber.

Forms of Shaft Linings.—Circular and elliptical forms for shaft linings are necessary when stone and brick are used, and are obviously to be preferred when using concrete unless concrete blocks are employed. Several rectangular concrete shaft linings have been successfully constructed in the United States, but practice probably favours the elliptical forms.

The principal reasons for choice of the circular or elliptical forms are strength and cheapness; but circular and elliptical forms are not usually chosen, for reasons of economy of space. However, only one-half the thickness of concrete is usually necessary when the curvilinear forms are employed; thus the size of excavation (rock-section) for the lining is actually reduced, and the cost of the concrete is practically halved. This is brought out to advantage on comparing the total cost of a shaft with an elliptical lining with one having a rectangular section, the two having the same accommodations for hoisting with regard to size of compartments, ladder and air-ways, and equal strength. The costs were £25* and £28 per ft. depth. The cost of timber lining under similar conditions would be approximately £19 4s. per ft. The costs of the elliptical and rectangular forms of concrete linings thus exceeds that of timber by 25 and 45 per cent. respectively.

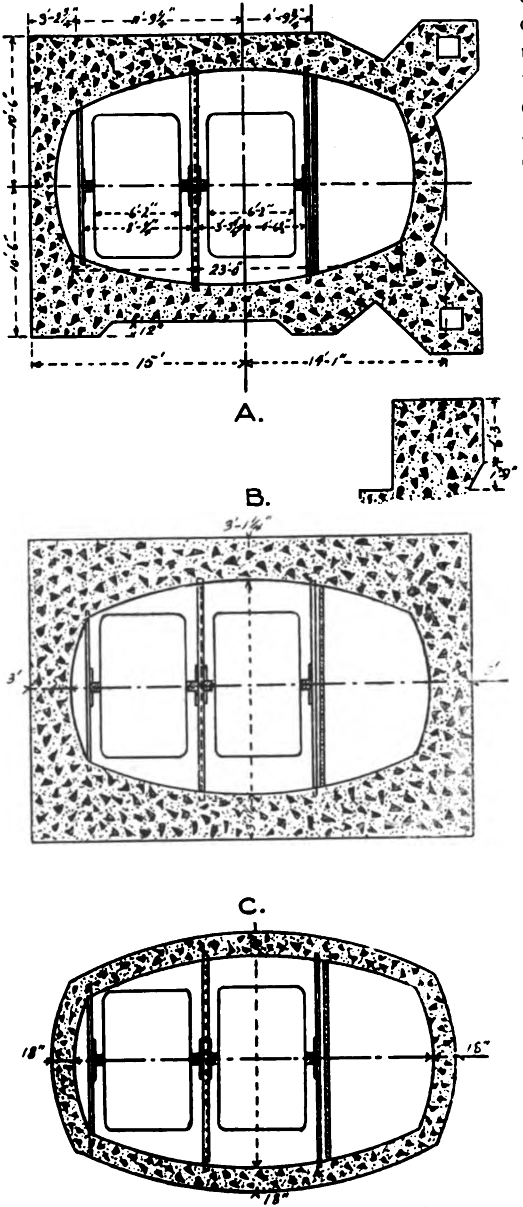


Fig. 1. A 855

The lining of inclined shafts, even with moderately high inclinations, does not differ materially from that of galleries and tunnels. There are two general forms of linings employed in the mines and tunnels of the United States, depending largely upon whether there are one or more lines of track. More than one line of track means in shaft work at least two and often three or more compartments, in which case the roof is usually arched. The rectangular and elliptical forms are usually employed in gangways and tunnels with only one track.

Probably the most extensive linings for steeply inclined shafts are to be found in the Lake Superior copper region, on Keweenaw Point, Michigan. Here the shafts are usually sunk on the lodes which dip from 35° to 80° with the horizontal. Arched concrete linings, in which room is provided for two hoisting compartments and a man-way, are constructed from surface to bed-rock, and often through 40 to 80 ft. of glacial drift, composed of sand, gravel, and boulders. This surface-wash and accumulation are almost invariably water-bearing, which condition materially increases the difficulties of construction. The linings are carefully connected with the bed-rock, drainage holes being provided through which excess of water can escape, thus maintaining a low head and reducing the danger of disturbing the concrete by percolation of water.

---

* American cost (5 dollars = £1).

Shaft and pump stations in many coal and metal mines of the United States are provided with concrete linings. Further, underground offices, hospitals, lamp rooms, and stables are now largely constructed of concrete. Re-lining of gangways, formerly timbered, with brick and concrete is the usual practice in the large coal mines throughout the States.

ILLUSTRATIONS OF CONCRETE SHAFT LININGS.

The Coal Department of the Lackawanna Railroad Company re-lined at least four shafts in their collieries in the vicinity of Sevanton, Pennsylvania. These linings were constructed of reinforced concrete and of a rectangular form. They connected the surface with bed-rock and passed through from 60 to 75 ft. of wash.

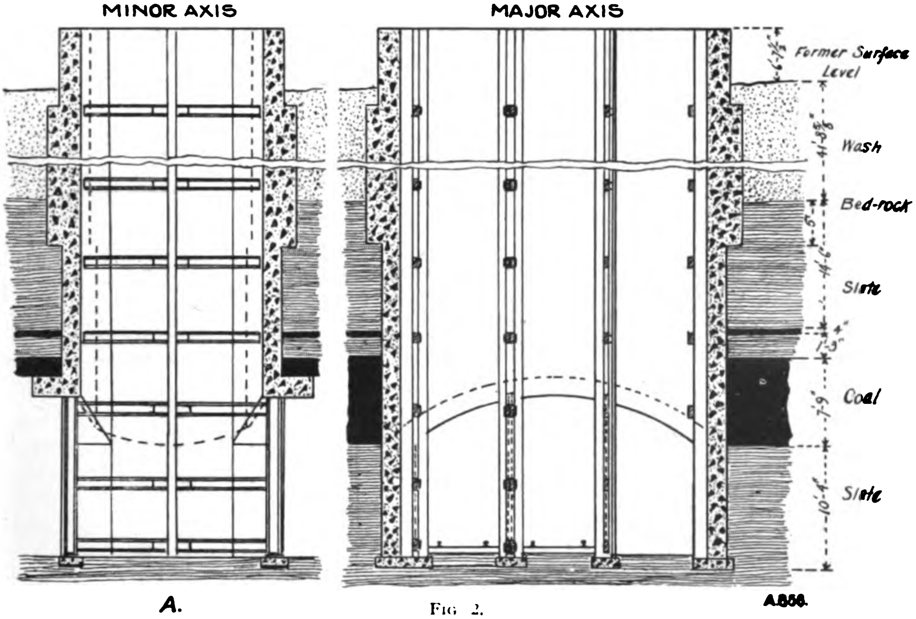


Fig. 2.

Two elliptical shaft linings were constructed on properties of the United States Steel Corporation; one being located at Tug River, West Virginia, while the other is at Bridgeport, Pennsylvania.

The Bridgeport Shaft.—The elliptical shaft lining at Bridgeport is 23 ft. by 15 ft., inside measurement, on the major and minor axis. The 81 ft. of lining was varied with depth, having three sections, as shown in *Fig.* 1. This lining was put down as a sinking-lining or drop-shaft, being provided with a heavy timber shoe with an angle-iron cutting edge. The dimensions of the shoe corresponded to that of the middle section of the lining (see B, *Fig.* 1). Some 30 ft. of forms were built upon the shoe, after it had been levelled up in the initial excavation, and the concrete was placed, smoothing being done by running a long-bladed shovel up and down next to the form. Ten days were allowed for the setting of the concrete, after which the outside members of the forms were removed.

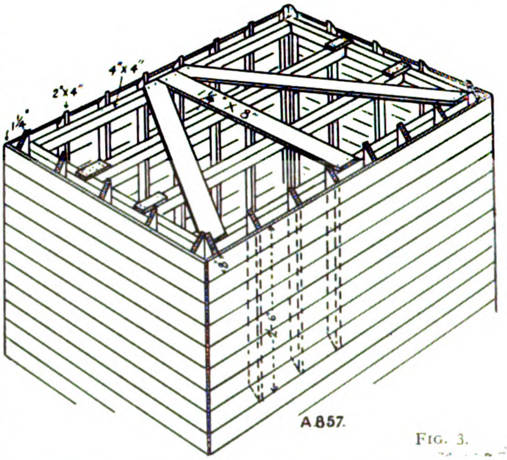


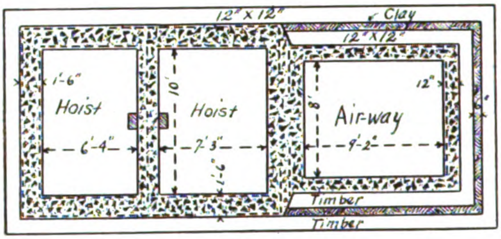
FIG. 3.

Settlement of the lining was accomplished and controlled by carefully and evenly removing material from beneath the shoe, which method of procedure was continued until the shoe rested upon a hard slate capping the coal. Some 5 ft. lower down a foundation ring was cut in the slate and a ring of concrete was built up to the drop-shaft above, thus completing the middle section of the lining the cross section of which corresponds to B in *Fig.* 1.

The sinking of the shaft was then continued through the underlying coal and to a depth of 10 ft. below it, thus completing the shaft excavation. This portion of the shaft was then lined, but with gangway connections left (see *Fig.* 2), connection being made with section B above (see C, *Fig.* 1).

The upper portion of the lining was then built, 7 ft. deep, which constitutes the capping of the lining, and serves as a foundation for the tipple above (see A, *Fig.* 1).

Sweepage of water, when excessive, was guarded against during construction by placing a strip of canvas against the rock wall and filling in the space between it and the forms with concrete. Further 1 or 2 in. iron pipes were laid, the concrete being built around them, thus permitting the escape of percolating waters. When the concrete had set, the pipes were capped and the flow of water was checked.



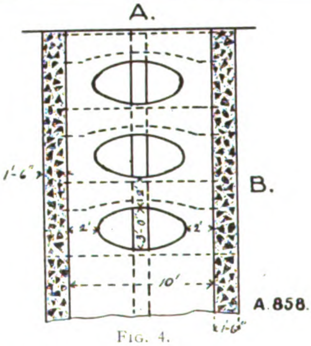


FIG. 4.

The approximate cost of this work was as follows:

		£ s. d		£ s. d.
Stone	... per ft. depth	1 3 9	... per cu. yd.	0 4 0
Sand ...	,,	0 7 3	.. ,,	0 1 3
Cement ...	,,	3 16 9	... ,,	0 13 0
		LABOUR.		
Mixing		£0 15 6	.. ..	£0 2 8
Placing		0 13 8	... ...	0 2 5
Firemen and Pumpmen		0 8 9	... ...	0 1 6
		£1 17 11		£0 6 7
		FORMS.		
Lumber		£0 7 5	... ...	£0 1 3
Making		0 11 11	... ...	0 2 1
Placing		0 19 5	... ...	0 3 4
		£1 18 9		£0 6 8

FORMS—*continued.*

		£ s. d.		£ s. d
Platform for starting upper section	per ft. depth	0 3 10	... per cu. yd.	0 0 8
Superintendence	,,	0 12 1	... ,,	0 2 1
Plant	,,	0 1 2	... ,,	0 0 3
Oil	,,	0 0 10	... ,,	0 0 2
Sundry	,,	0 4 3	... ,,	0 0 9
Total ...	,,	£1 2 2	... ,,	£0 3 11

When the lining was completed the shaft was divided into three compartments by setting three lines of 8 in. by 12 in. angle-buntons into the concrete lining, holes being chiselled out and fresh concrete rammed in after the buntons were in place.

An attempt made at the Tug River shaft to use cast-iron bunton-pockets, which were built into the lining, proved a failure owing to the greatly increased leakage at those points.

This lining was designed by Mr. F. A. Macdonald, chief engineer of the River Coal Company, and was placed by the Drago Construction Company.

It is evident that this lining is not a perfect ellipse in section, being a cross, as it were, between an ellipse and a rectangle.

The Manville Shaft.— The lining of this shaft is a good example of a rectangular form, but being a case of re-lining a timbered shaft the work did not present such serious difficulties as are usually encountered when sinking and lining are carried on at one and the same time. The shaft was originally lined with 12 in. by 12 in. timbers, built into two (an inner and outer) shells, between which was a 6 in. layer of clay.

The work of re-lining was begun at the bottom, on solid rock, and proceeded upward to the surface, and consisted in removing the inner lining of timber together with the clay packing and placing the concrete within the remaining shell of timber, which served as a temporary support for the walls. However, the removal of the lining was done in sections, and only slightly in advance of the concrete lining, and did not therefore endanger the work through possible collapse of the walls.

Forms were built of boards and planks, one for each of the compartments and of the desired size for the same (see *Fig.* 3). The outer lining of the shaft served as one side of the mould, thus determining the thickness of the concrete. In the construction of the lining for the air-way no part of the former shaft lining of timber was removed, the concrete lining being built between the inside form and the shaft timbering. The cross section of this portion of the shaft was consequently reduced somewhat, whilst that of the other two compartments was practically unchanged (see A, *Fig.* 4).

As each successive section of concrete lining was placed and had become sufficiently set to stand, the form was removed and set at a higher level. The ends of the vertically placed timber of each form were bevelled in order that they might engage the ends of similar pieces in the form below.

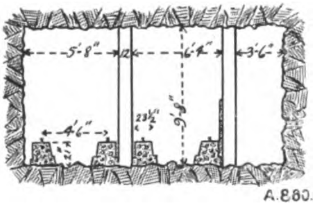


FIG. 6.

Expanded metal was employed in this work, and consisted of sheets in the concrete next to both inner and outer surfaces of the lining, as shown by the broken lines in A, *Fig.* 4. Sheets of expanded metal 6 ft. by 8 ft. and $\frac{3}{16}$ in. thick were employed, the ends overlapping at breaks.

Concrete partitions serve as dividers in the shaft, which are broken by openings formed in them, in reality sub-dividing the partition into individual dividers or buntons. The openings are oval in shape, and besides reducing the amount of concrete used, facilitate the placing of cage guides, which are bolted to the bunton partition by $\frac{7}{8}$ in. bolts. The whole partition is reinforced by $\frac{5}{16}$ in. rods, which were built into the concrete, being bent into a sinuous form to prevent slipping in the concrete (see B, *Fig.* 4).

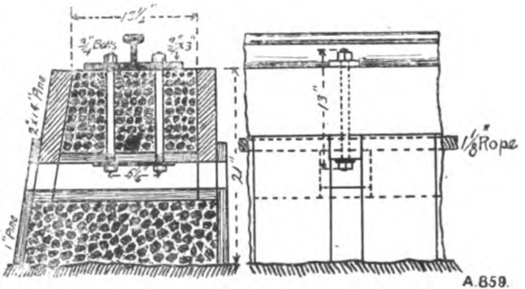


FIG. 5.

The composition of the concrete used in this work was 1 per cent. cement, 2 parts sand, and 5 parts broken stone.

The work of re-lining this shaft, as well as others of the Lackawanna Railway Company, was in the charge of Mr. J. F. Snyder, chief engineer of the coal department.

Concrete Stringers for Tracks in Inclined Shafts.— Aside from the use of concrete in lining the shafts of the Lake Superior copper mines, it is employed in a variety of ways both in the mine workings and in the shafts. Probably the most important use to which it has been put is the support of the tracks, being built into large longitudinal stringers upon which the rails are mounted and to which they are securely bolted. Such stringers are in use at the Almeek, Mohawk, and in several other mines in the vicinity of Calumet, Michigan.

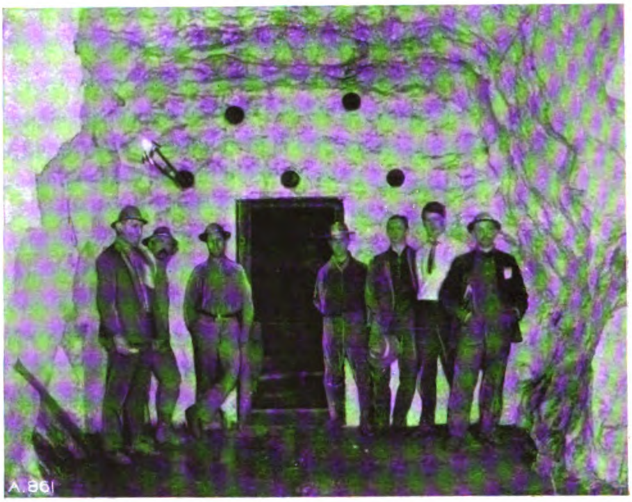


Fig. 7.

The Almeek Shaft Stringers. — This shaft has a dip of 42° from the horizontal. Preparatory to placing the stringers the foot-wall or floor of the shaft is cleared of all loose material and the mould timbers are placed. Before placing the concrete, the space between the walls of the mould flushed out to bed-rock, thus ensuring a clean face for the concrete. The depth of the stringers is about 22 in. when measured normal to the dip of the shaft. The construction of these stringers with internal bincher (mould wire rope) and method of attaching track are shown in *Figs.* 5 and 6.

The concrete for this work was composed of 1 part Portland cement, 3 parts sand, and 5 parts broken stone. With cement at 7s. 8d. per barrel, sand 2s. 1d. per cu. yd., and crushed stone 4s. 6d. per cu. yd., the cost of 90 linear ft. of track (two stringers) was £40 3s. 6d., which includes labour, but not the cost of the moulds. The average cost per ft. of track was 9s., or probably 18s. per ft. for a two-track shaft. It is claimed that the expense of thus equipping a shaft is less than when timber is employed, and as a further advantage the fire risk is greatly reduced.

Concrete stringers have been in use in the Almeek mines for over two years and have proved very satisfactory. The work was done under the superintendence of W. J. Wren.

Underground Powder Magazines.— A majority of the large mines have powder magazines underground, which is the case particularly with the copper mines of Northern Michigan. As a usual thing the magazines consist of blind drifts or old stopes walled off from the rest of the workings and provided with thawing racks and steam pipes. Such a magazine is shown in *Fig.* 7, and is in the Mohawk mine, No. 3. The floor is concrete, with a drain which leads to and under the door-sill. The open end of the drift has been walled off with an 18 in. concrete partition in which are provided ventilation openings, also others for steam pipes, electrical lighting wires, etc. A heavy iron door effectively closes the magazine and guards against interference with powder and appurtenance.

A TEN-STOREY REINFORCED CONCRETE BUILDING IN PITTSBURG, U.S.A.

We have been recently presenting particulars of large warehouses and factories erected in reinforced concrete in this country. The present article illustrates a tall ten-storey building recently completed in the United States, which will give an excellent idea of what can be put up in reinforced concrete in the way of tall so called "sky-scrapers."

We are indebted to the architects, Messrs. Ballinger and Perrot, of Philadelphia, for our illustrations, and to the "Engineering News" for the technical data.—ED.

REINFORCED CONCRETE OFFICE BLOCK FOR THE BERNARD GLOEKLEN CO. OF PITTSBURG, U.S.A.

A REINFORCED concrete warehouse has recently been completed in Pittsburg which, on account of its size and of some details of construction and exterior finish, possesses a more than ordinary interest. The building, which is to be occupied by the Bernard Glockler Co., in connection with the manufacture of refrigerators, store fixtures,

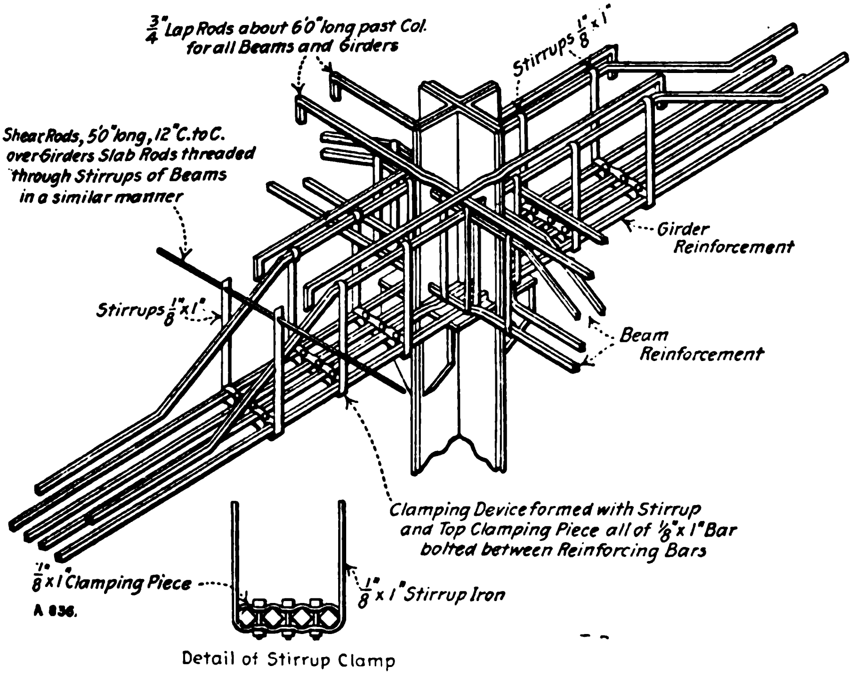

$\frac{3}{4}$" Lap Rods about 6'0" long past Col. for all Beams and Girders
Stirrups $\frac{1}{8}$" x 1"
Shear Rods, 5'0" long, 12" C. to C. over Girders Slab Rods threaded through Stirrups of Beams in a similar manner
Girder Reinforcement
Stirrups $\frac{1}{8}$" x 1"
Beam Reinforcement
Clamping Device formed with Stirrup and Top Clamping Piece all of $\frac{1}{8}$" x 1" Bar bolted between Reinforcing Bars
$\frac{1}{8}$" x 1" Clamping Piece
$\frac{1}{8}$" x 1" Stirrup Iron
A 836.
Detail of Stirrup Clamp

FIG. 1. THE GLOEKLER BUILDING.
(Isometric view of column-girder connections.

machinery and supplies, has ten stories and a basement, and occupies an area of 82 ft. by 100 ft. From the first floor level to the top of the cornice the height is 144 ft. 9 in., and from first floor to top of basement floor the depth is 13 ft., the average storey

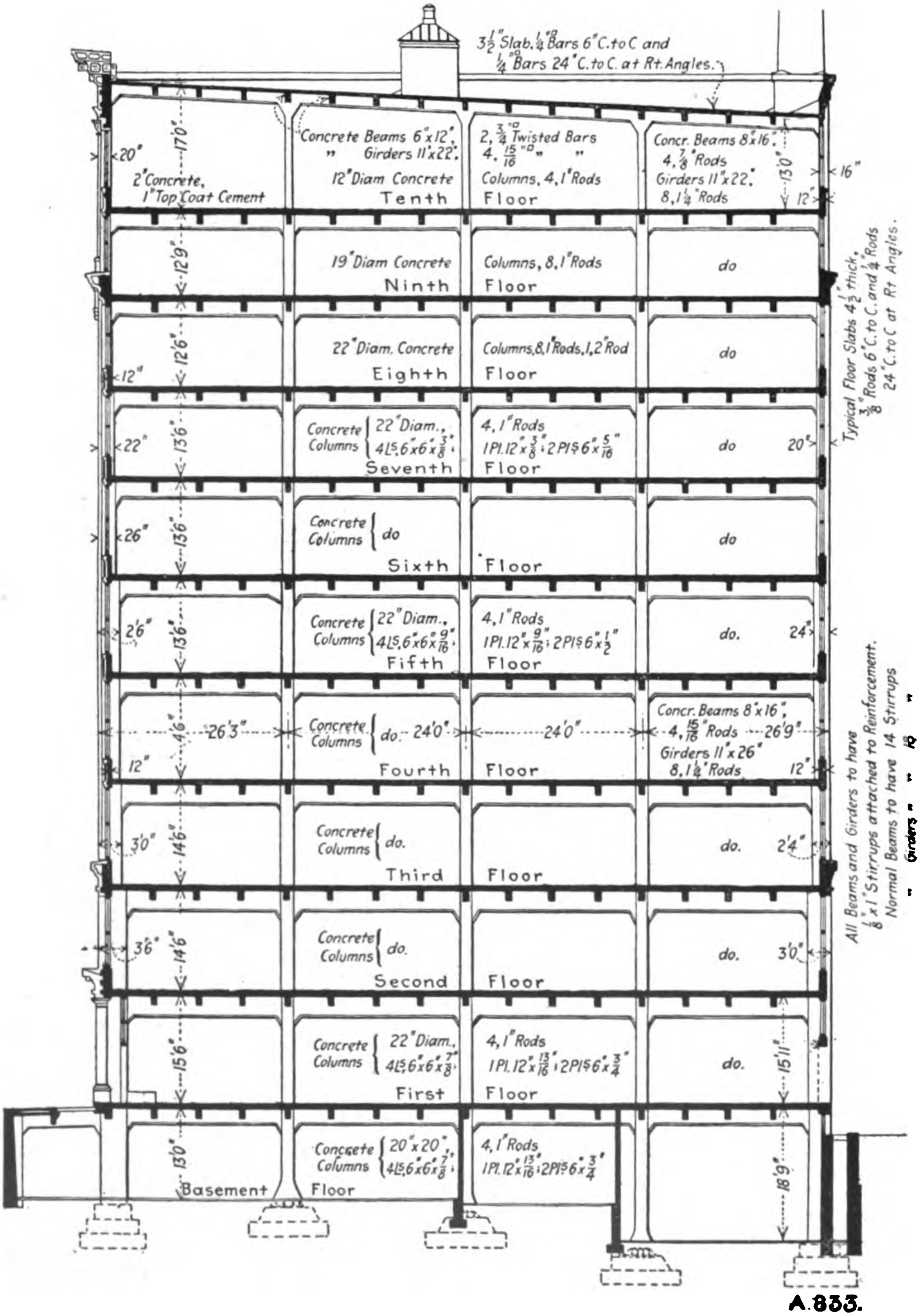

3½" Slab. ¼" Bars 6" C. to C and ¼" Bars 24" C. to C. at Rt. Angles.
20"
17'0"
2" Concrete, 1" Top Coat Cement
Concrete Beams 6" x 12". " Girders 11" x 22".
12" Diam Concrete
Tenth Floor
2, ¾" Twisted Bars 4, 15/16" " "
Columns, 4, 1" Rods
Concr. Beams 8" x 16". 4, 7/8" Rods
Girders 11" x 22". 8, 1¼" Rods
13'0"
16"
12"
12'9"
19" Diam Concrete
Ninth Floor
Columns, 8, 1" Rods
do
12"
12'6"
22" Diam. Concrete
Eighth Floor
Columns, 8, 1" Rods, 1, 2" Rod
do
Typical Floor Slabs 4½" thick, 3/8" Rods 6" C. to C. and ¼" Rods 24" C. to C at Rt Angles.
22"
13'6"
Concrete Columns 22" Diam., 4 Ls. 6" x 6" x 3/8";
Seventh Floor
4, 1" Rods 1 Pl. 12" x 3/8"; 2 Pls. 6" x 5/16"
do
20"
26"
13'6"
Concrete Columns do
Sixth Floor
do
2'6"
13'6"
Concrete Columns 22" Diam., 4 Ls. 6" x 6" x 9/16";
Fifth Floor
4, 1" Rods 1 Pl. 12" x 9/16"; 2 Pls. 6" x ½"
do.
24"
26'3"
14'6"
12"
Concrete Columns do.
24'0"
Fourth Floor
24'0"
Concr. Beams 8" x 16", 4, 15/16" Rods
26'9"
Girders 11" x 26" 8, 1¼" Rods
12"
All Beams and Girders to have 1/8" x 1" Stirrups attached to Reinforcement. Normal Beams to have 14 Stirrups
" Girders " " 18 "
3'0"
14'6"
Concrete Columns do.
Third Floor
do.
2'4"
3'6"
14'6"
Concrete Columns do.
Second Floor
do.
3'0"
15'6"
Concrete Columns 22" Diam., 4 Ls. 6" x 6" x 7/8";
First Floor
4, 1" Rods 1 Pl. 12" x 13/16"; 2 Pls. 6" x ¾"
do.
15'11"
13'0"
Basement Floor
Concrete Columns 20" x 20", 4 Ls. 6" x 6" x 7/8";
4, 1" Rods 1 Pl. 12" x 13/16"; 2 Pls. 6" x ¾"
18'9"
A.833.

Fig. 2. Gloekler Building (Vertical section).

height being about 14 ft. 5 in. The second, third, and fourth floors were designed for a live load of 300 lbs. per sq. ft., and the others for 250 lbs. per sq. ft., with a factor of safety of four throughout. It will be noted that these floor loads are from two to three times as great as the usual loads for high buildings of the ordinary steel frame type. The design was originally made for a steel skeleton construction, but was afterward changed to the present design at an estimated saving of £6,000. The general plan of the building remained the same.

Particular attention has been paid to the architectural treatment of the front of the building, both as to the lines and fineness of the texture. While in the rest of the building the ordinary 1 : 2 : 4 gravel concrete mixture was used, the front face, for the first two stories, was built with a mixture of 1 part cement to 3 parts marble dust, and above the second storey a finely ground light-coloured stone known as lignier was used instead of marble dust. The marbled face from the first floor line up to and including the belt course at the third floor is finished with a "crandalled" surface (*Fig.* 3); above this, the front, the remaining exterior walls, and the interior walls were treated with wire brushes and then finished with a cement wash applied with brushes, filling all voids and leaving a smooth surface. The Ionic columns and cornices in the upper storeys were moulded separately on the ground and set in place with the mass work moulded around them.

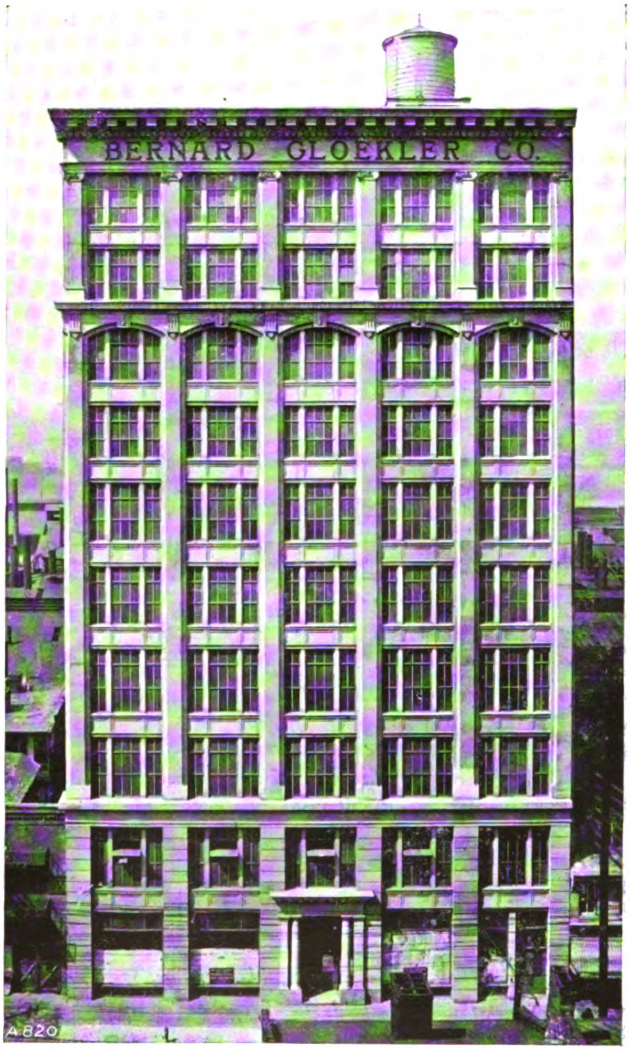


FIG. 3. THE GLOEKLER BUILDING, PITTSBURG
(Front view, erected in reinforced concrete).

Fig. 2 shows a vertical section through the building and *Fig.* 5 a typical floor plan. The columns and outer piers are founded on stepped concrete footings, resting on earth foundations. The general system of construction follows in the main the usual practice in reinforced concrete buildings, with the following details of make-up and reinforcement.

The following are the chief particulars of interest :—

COLUMNS.—Circular concrete interior columns, varying from 22 in. in diameter in the 1st storey to 15 in. in the 10th storey, are used throughout the building, with the exception of the basement, where concrete columns 24 in. square are used. There are four rows of these columns spaced 15 ft. 10 in. in one direction and 24 ft. in the other direction. In order to avoid using larger size columns structural steel cores are used from the basement to the level of the 8th floor. These cores are made of star sections, both for simplicity of construction and to readily permit the tamping of the concrete about them. They are composed of four 6×6 in. angles, varying in thickness from ⅞ in. in the basement to ⅜ in. at the 7th storey, and one 13-in. and two 6-in. plates, varying from ¾ in. to $\frac{5}{16}$ in. in thickness. Angle brackets are riveted to the column cores just below the floor line at each storey to receive the concrete beams and girders. Columns having structural steel reinforcement contain in addition four 1-in. rods placed 3 in. from the surface. In the 8th storey the columns contain one 2-in. rod in the centre and eight 1-in. rods: the 9th storey, eight 1-in. rods, and the 10th storey columns, supporting the roof, four 1-in rods. These rods are fastened together with ¼-in. wire ties spaced every 12 in., except where steel cores occur, where they are spaced every 24 in. Brackets 12 in. deep, making an angle of about 60° with the horizontal, are used under beams and girders where these connect with the columns.

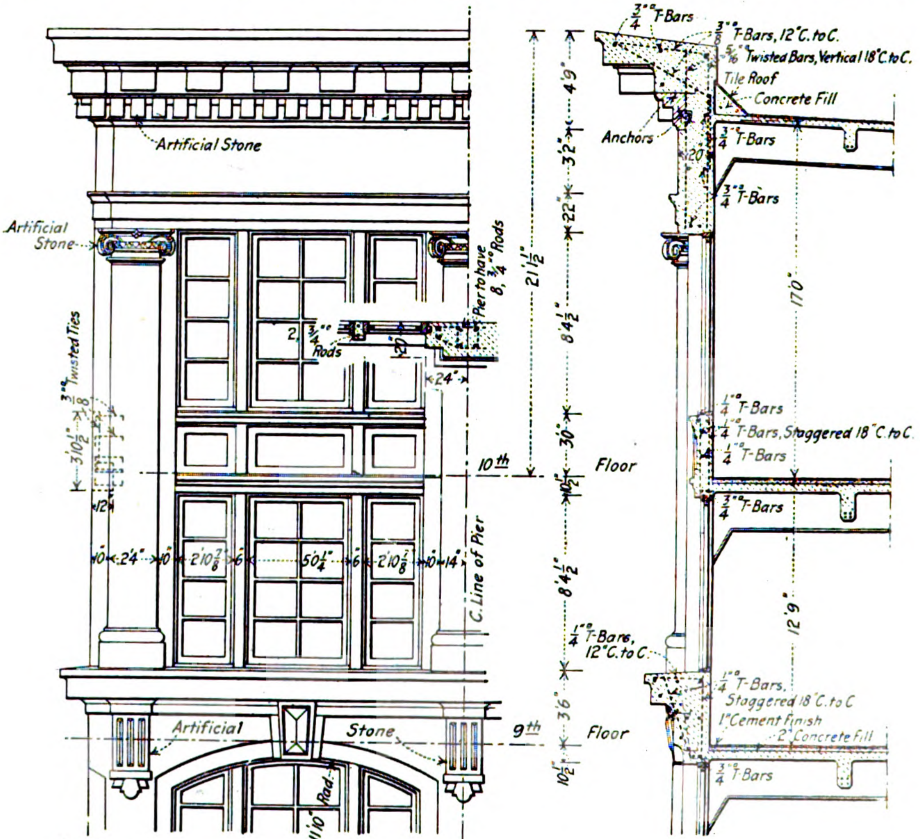


FIG. 4. GLOEKLER BUILDING (Detail of wall and floor).

The wall columns vary considerably in size according to the loads carried, and are reinforced with round rods fastened together with ¼-in. wire ties every 12 in. These rods are placed a distance of 3 in. from the faces of the columns, the outside concrete being considered as fireproofing.

Where the steel column cores occur the column rods lap 3 ft., and are wired together. Where the cores are not used the ends of the rods are sawed square and butted together at splices, with pipe sleeves 10 in. long to keep the rods in alignment. Iron base plates and pipe sockets are provided at the column footings to provide a bearing for the column rods.

GIRDERS.—All floor girders are 11 × 22 in., with the exception of the 2nd, 3rd. and 4th floors, which are 11 × 26 in. The roof girders are also 11 × 22 in. All have a span of 24 ft., and are spaced 16 ft. c. to c. Each girder is framed into by three floor beams on each side. All the floor girders are reinforced with eight 1-in. twisted rods, and the roof girders with four 1¼ in. twisted rods. Where floor and roof beams frame into girders on opposite sides, a ¾-in. rod 4 ft. long, with 3-in. hooked ends, is provided in the top of and at right angles to the girder and projecting into each beam to form a tie. Where the ends of the girders join at the columns, two ¾-in. rods, 6 ft. long, are placed in the tops of and projecting into each girder, forming a tie. There were also placed in the tops of and at right angles to the girders ½ in. rods 5 ft. long projecting an equal distance each side of the centre of the girder into the adjacent slab to resist shear.

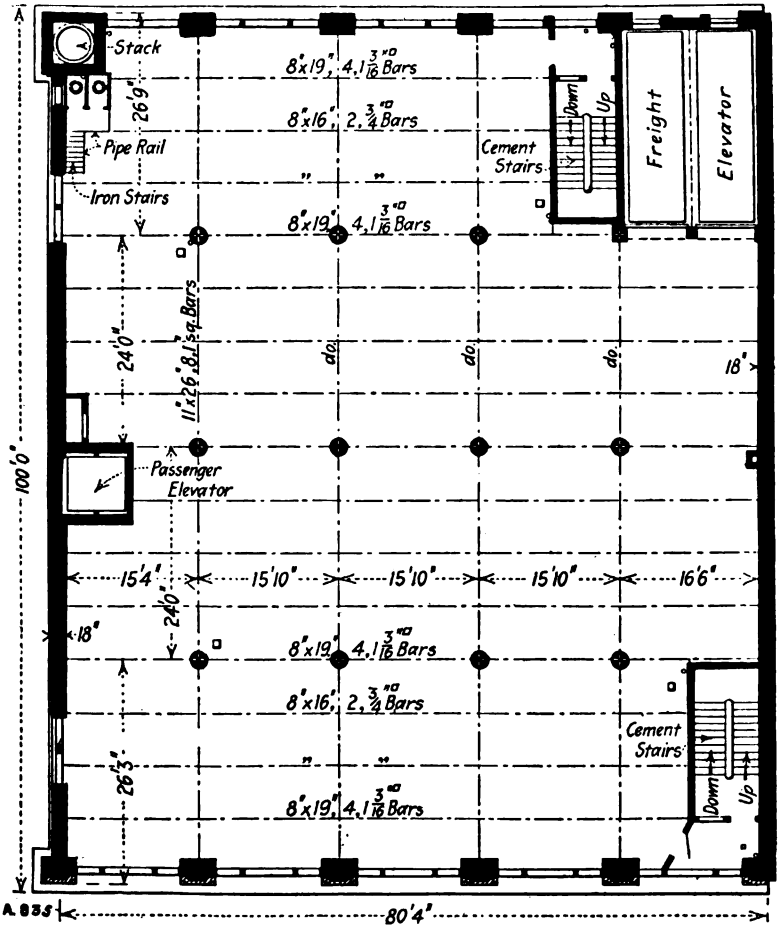


FIG. 5. GLOEKLER BUILDING (Typical floor plan).

Beams for all floors are 8 × 16 in., and those for the roof are 6 × 16 in. All have a span of 16 ft. and are spaced 6 ft. c. to c. Beams for the 2nd, 3rd, and 4th floors are reinforced with four ⅝-in. square twisted steel bars, and for the remaining floors with four ¾-in. twisted bars; the roof with two ¾-in. bars.

All beam and girder reinforcement was bent and framed according to the system of the Unit Concrete Steel Frame Co. A typical reinforcement is shown in *Fig.* 1,

Straight rods were delivered adjacent to the building site, and those intended for the beams and girders were then bent into the desired shape and securely fastened together. Attached to these frames are $\frac{1}{8} \times 1$ in. U-shaped vertical stirrups which extend into the floor slab and have holes punched in their upper end through which the slab rods extend, forming a bond with the slab. Typical beams have 14 stirrups and typical girders 18 stirrups. These frames were placed in the forms as one piece, and by means of special sockets were rigidly fastened in the position intended by the design. These sockets were ordinarily spaced 4 ft. apart and left in the concrete to be used in the completed building for the attachment of shafting and other fixtures, sockets in addition to those used in the construction being put in where desired. Steel reinforcement for the beams and girders is placed 2 in. from the under side of same, the concrete below being considered as fireproofing.

The reinforcing rods for typical beams and girders are placed in two layers, half in each layer, the bottom layer running straight from one end of the beam to the other, and the upper layer running parallel with the lower in the centre of the span for about 50 per cent. of its length span and bent up toward the top at the end of the beam.

FLOOR SLABS.—All floor slabs are $4\frac{1}{2}$ in. thick, and are reinforced with $\frac{5}{16}$-in. twisted square bars spaced 6 in. c. to c., with $\frac{1}{4}$-in. twisted square bars spaced 2 ft. c. to c., running at right angles. The roof slab is $3\frac{1}{2}$ ins. thick, with $\frac{1}{4}$-in. bars 6 ins. c. to c., and at right angles $\frac{1}{4}$-in. bars 2 ft. c. to c. For both floor and roof slabs the reinforcement is placed 1 in. from the under side of the slabs. Small threaded cast-iron sockets were placed on the under side of the floor slabs for the support of electric wiring. Iron pipes are also placed in the beams and girders directly below the under side of the floor slab for the electric wires. The finished floor consists of 2 in. of concrete placed directly upon the top of reinforced concrete floor slab with a 1-in. top coat of cement and sand laid off in blocks.

WALLS.—With the exception of the main entrance and the dentil course just above it, which are of artificial stone, the exterior is entirely monolithic. The side walls of the building are constructed to meet the requirements of party walls, and vary in thickness from 24 ins. in the basement to 14 in. in the 8th storey. The reinforcement consists of $\frac{1}{2}$-in. twisted square bars in pairs placed horizontally 2 ft. c. to c., and $\frac{1}{2}$-in twisted square rods placed vertically 2 ft. c. to c., staggered, the reinforcement being placed 3 in. from the faces of the wall. For the 6 and 8-in. interior partitions $\frac{1}{4}$-in. twisted square bars are placed vertically every 18 in., staggered, and $\frac{1}{4}$-in. twisted square bars placed horizontally every 18 in., staggered.

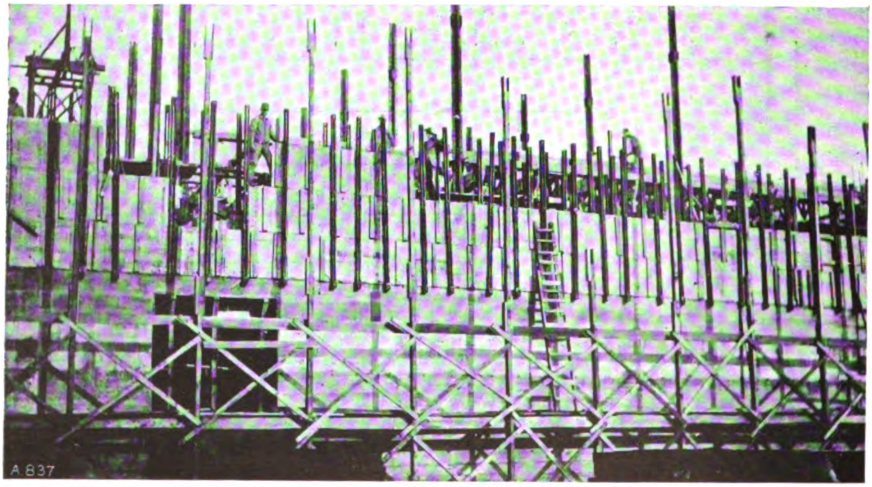


FIG. 6. GLOEKLER BUILDING.
(Showing forms for the concrete).

Some REINFORCED CONCRETE BRIDGES in Italy

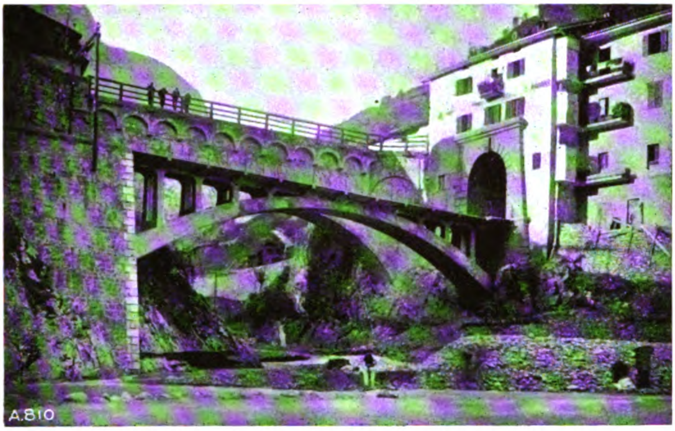


Fig. 17. Reinforced Concrete Bridge over the Brembilla River.

No long technical description is necessary to indicate the lesson we wish to teach, namely, that foreign countries consider reinforced concrete practical and economical for every-day civil engineering purposes. A few illustrations suffice, and, in this instance, we present some excellent examples of Italian reinforced concrete bridge work constructed by Sig. Leonardi of Milan.—ED.

We publish a series of photographs illustrating the remarkable extent to which reinforced concrete construction has been adopted in Italy for the purposes of railway and other bridges. Some of the examples selected involved considerable difficulties in their

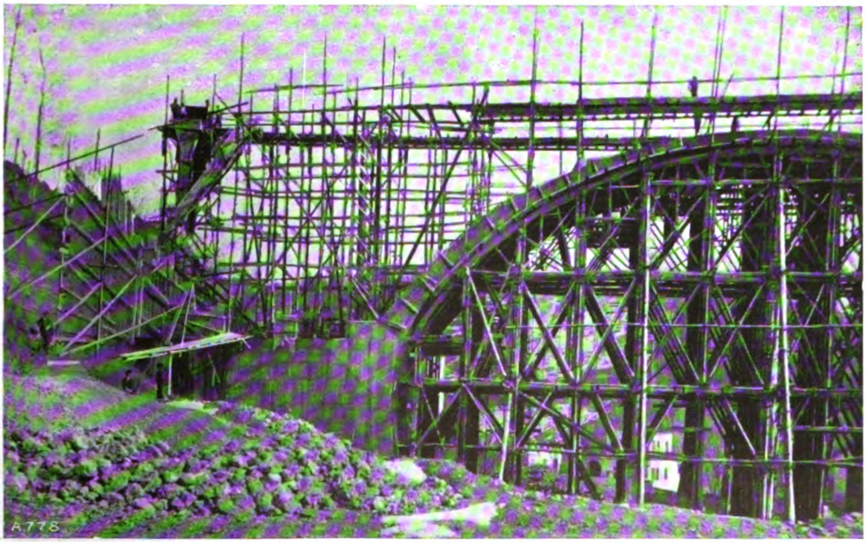
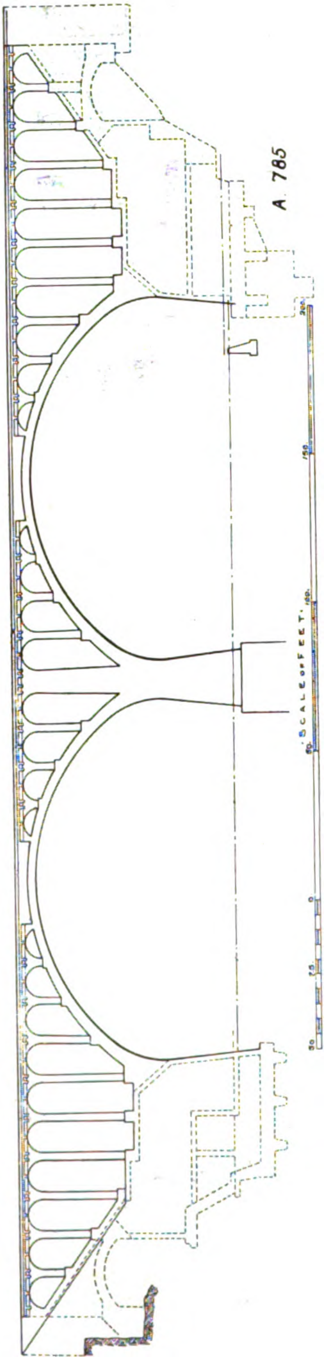
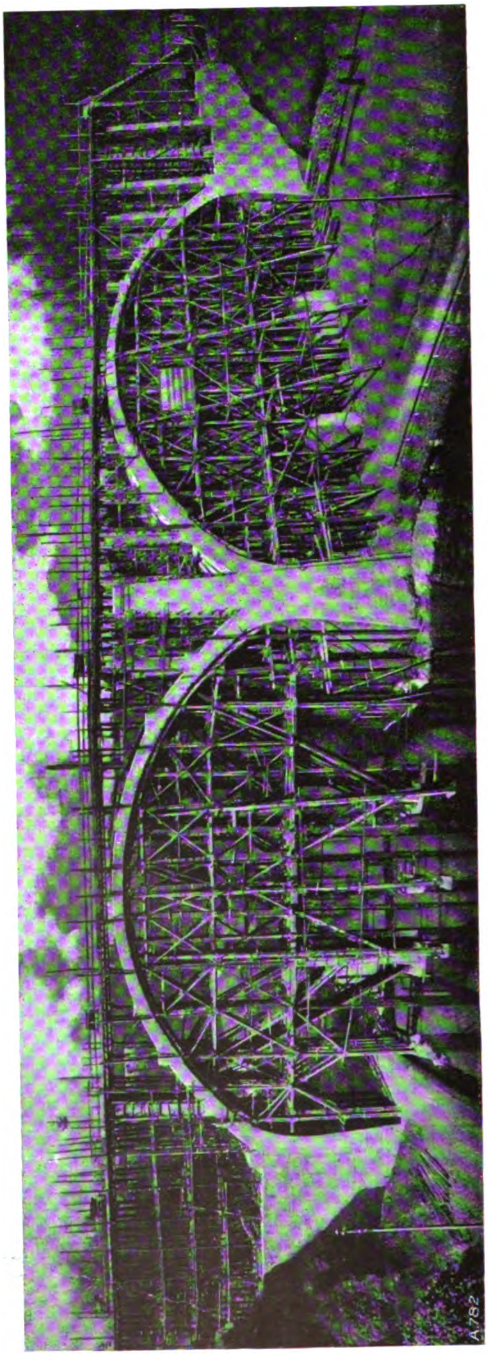


Fig 3. Reinforced Concrete Bridge over the Lambro Valley, Italy.
(Showing reinforced concrete arch in course of construction.)





Figs. 1 & 2. The Reinforced Concrete Bridge over the Lambro Valley, Italy.

construction, difficulties which have been overcome by the Italian engineers with great skill.

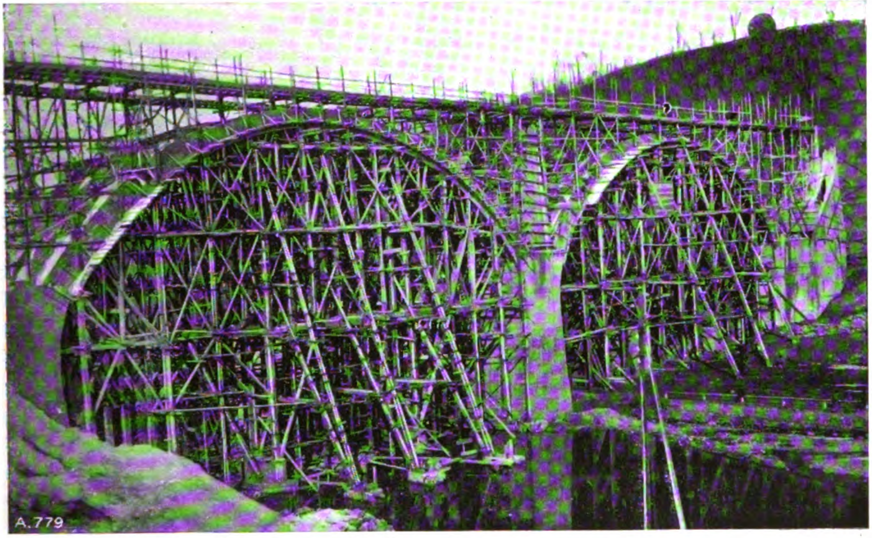
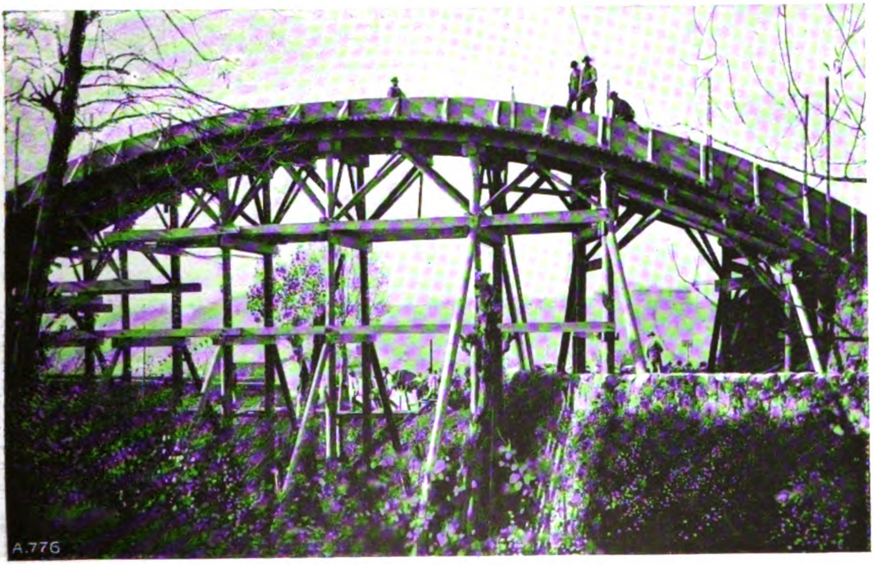


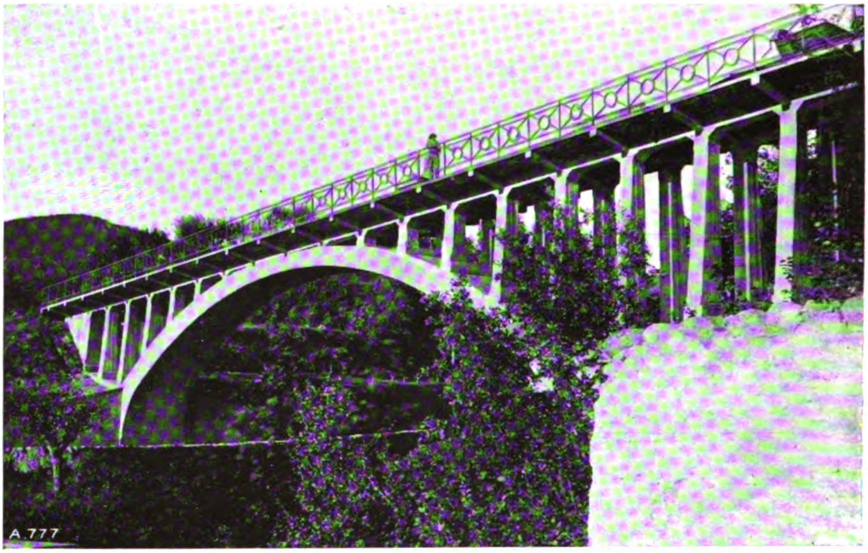
Fig. 4. Reinforced Concrete Bridge over the Lambro Valley.
(In course of construction.)

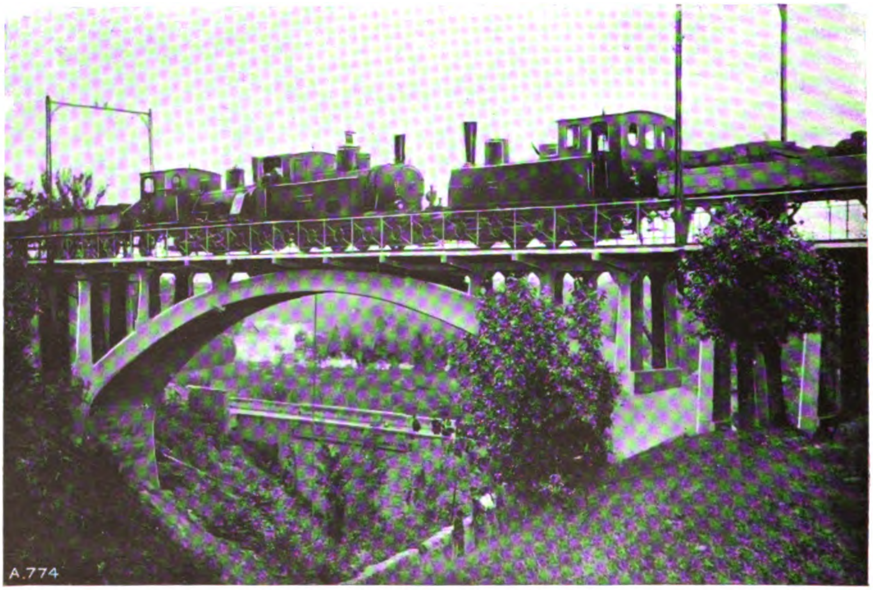


Figs. 5 & 6. Reinforced Concrete Bridge over the River Reno.
(Showing reinforced concrete arch in course of construction.)

The Lambro Valley bridge, of which the design is shown in *Fig.* 1, and views during construction in *Figs.* 2, 3, and 4, has two spans of 37·5 m. each, and is intended to carry road traffic and a steam tramway.

A bridge on the Valle Brembana electric railway, over the River Rino, is shown in outline in *Fig.* 5. *Fig.* 6 shows the centreing of the arch, and *Fig.* 7 the completed bridge. The total length in this case is 60 m., the span of the arch being 27·2 m. *Fig.* 8 shows a loading test in progress.





FIGS. 7 & 8. REINFORCED CONCRETE RAILWAY BRIDGE OVER THE RIVER RINO.

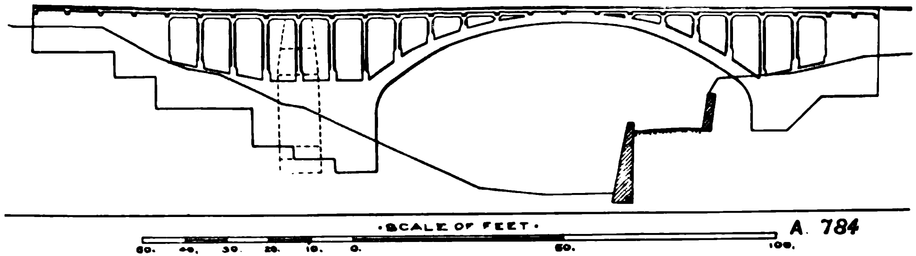
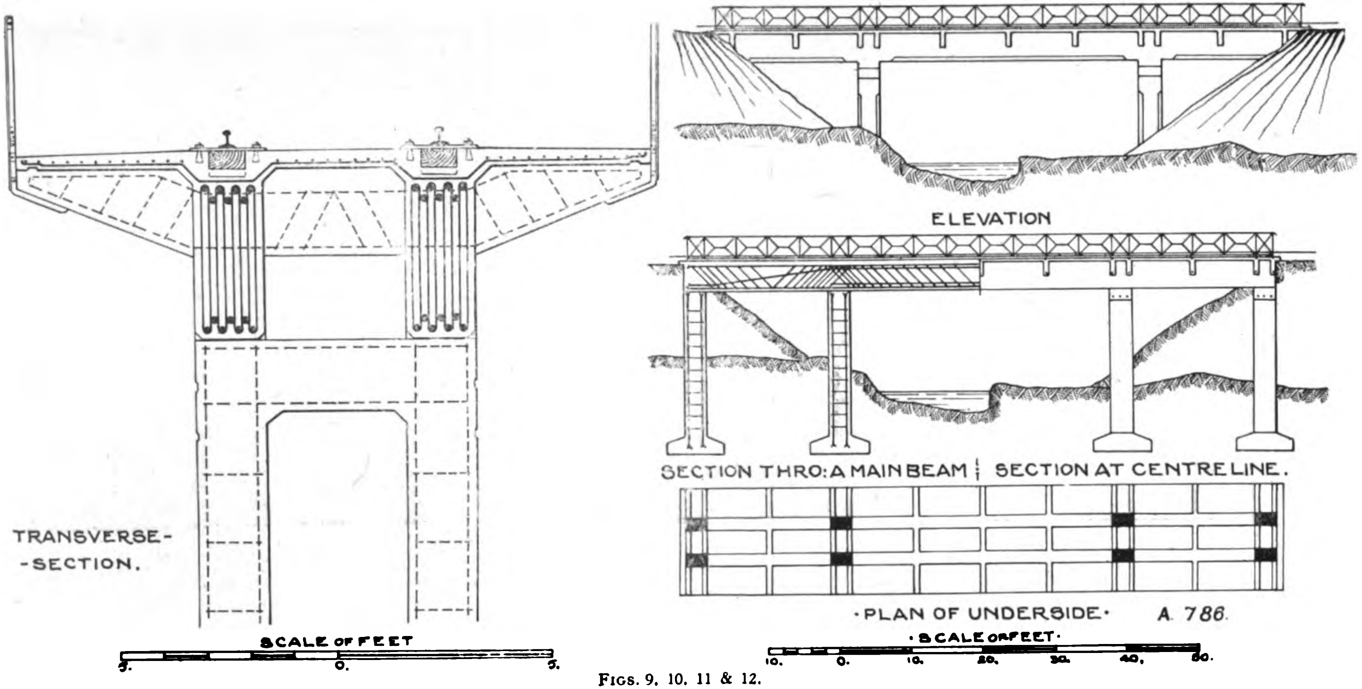


FIG. 5.

FIG. 5.
REINFORCED CONCRETE
RAILWAY BRIDGE OVER
THE RIVER RINO.

FIGS. 9 TO 12.
REINFORCED CONCRETE
BRIDGE OVER THE RIVER
QUISA.



FIGS. 9, 10, 11 & 12.

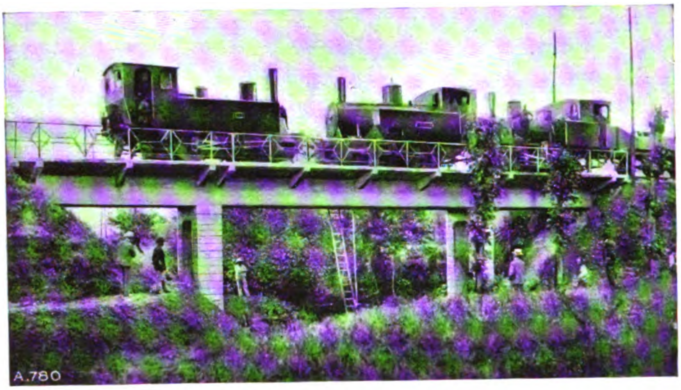


FIG. 13. REINFORCED CONCRETE RAILWAY BRIDGE OVER THE RIVER QUISA.

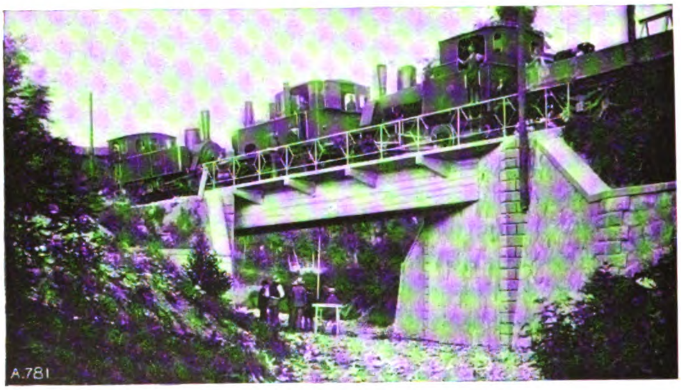


FIG. 14. REINFORCED CONCRETE RAILWAY BRIDGE AT PONTERANICA.

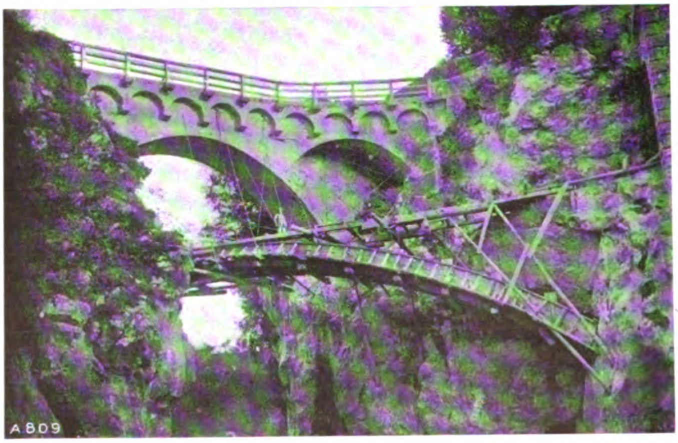


FIG. 15. REINFORCED CONCRETE BRIDGE OVER THE BREMBA AT THE GORGE OF SEDINA.
(Showing construction of arch under exceptional difficulties with suspended centering.)

Figs. 9, 10, 11, and 12 show the construction of a girder bridge on the same railway, crossing the River Quisa. The arrangement of the reinforcement will be clearly seen. A loading test is represented in *Fig.* 13.

The same electric railway has repeatedly adopted reinforced concrete for the construction of its bridges. The girder bridge over the Morla, at Ponteranica, is shown under load in *Fig.* 14.

A decidedly striking bridge is that which crosses the Bremba at the gorge of Sedina. This is illustrated in *Fig.* 15; *Fig.* 16 being a view taken during the process of construction. The span of the arch is 37·5 m. A similar arch, of 27·5 m. span, crosses the Brembilla, and is illustrated in *Fig.* 17.

These few examples, selected from many of a like character, will serve to show how deeply reinforced concrete has already entered into Italian engineering practice.

These bridges have all been constructed by Sig. F. Leonardi, of Milan, to whom we are indebted for our illustrations.

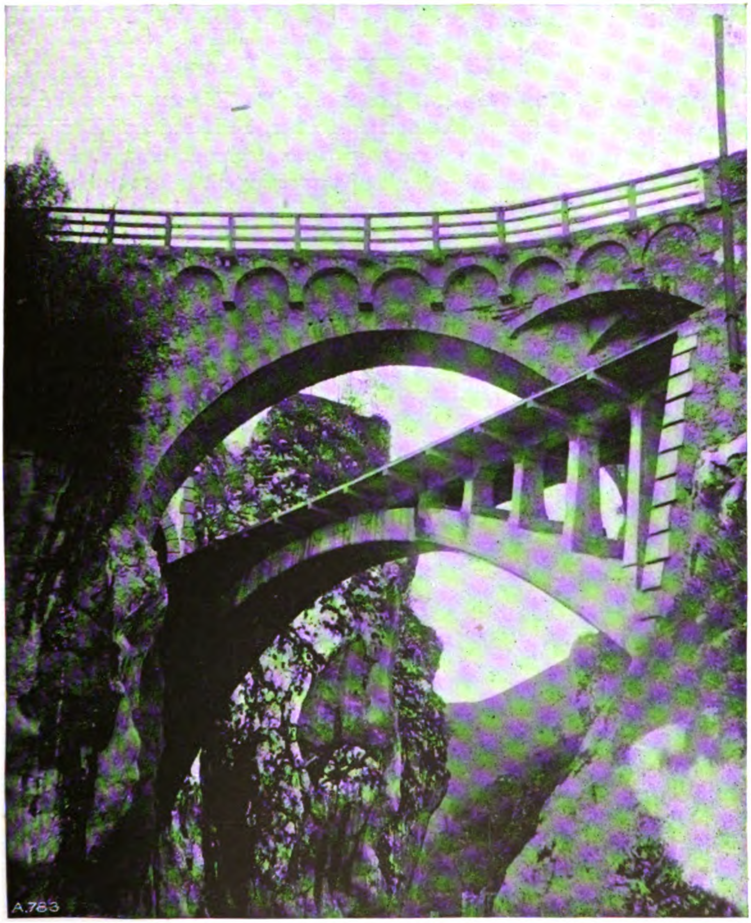
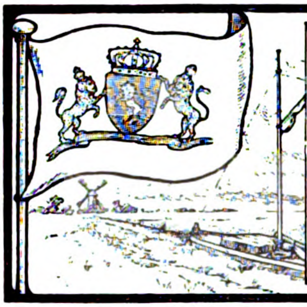


Fig. 16. Reinforced Concrete Bridge over the Bremba at the Gorge of Sidina. (Completed.)



REINFORCED CONCRETE SEA DEFENCES. II.

DUTCH EXAMPLES.

By H. HUISMAN, C.E., Zierikzee, Holland.

(Translated from the Dutch)

At a period when the question of coast erosion is occupying general attention, the article presented herewith, from the pen of Mr. H. Huisman, should be an interesting contribution on the subject of dykes for low-lying land, indicating as it does the great practical use and economy of reinforced concrete in this class of work.—ED.

IN the January issue of CONCRETE AND CONSTRUCTIONAL ENGINEERING the construction of dyke-walls according to the system devised by Mr. de Muralt, of Zierikzee, Holland, an engineer of the Dutch *Corps des Ponts et Chausées,* was described and illustrated. In this article the "De Muralt System" of protecting the slopes of dykes and sand-dunes will be dealt with. Reinforced concrete has been tried for such sea defences for many years in Germany, France, and other countries, but in the majority of cases has not met with much success, owing to the facings of slopes being destroyed by the thrust of the soil under them, produced by extremes of temperature.

Mr. de Muralt's method of facing slopes with concrete reinforced with sheets of expanded metal dates only from March, 1906, but has made rapid progress. The inventor claims for it the following advantages: (1) The construction and the principles upon which it is carried out prevent and obviate the mistakes and faults appertaining to previous concrete slope defences; (2) the remarkably simple construction allows of its being carried out by unskilled labour; (3) the resistance of slope protection on this system is very great; (4) the method is more economical than any other.

These claims have been tested and substantiated by the author, who has superintended the construction of several slope facings carried out on the De Muralt system.

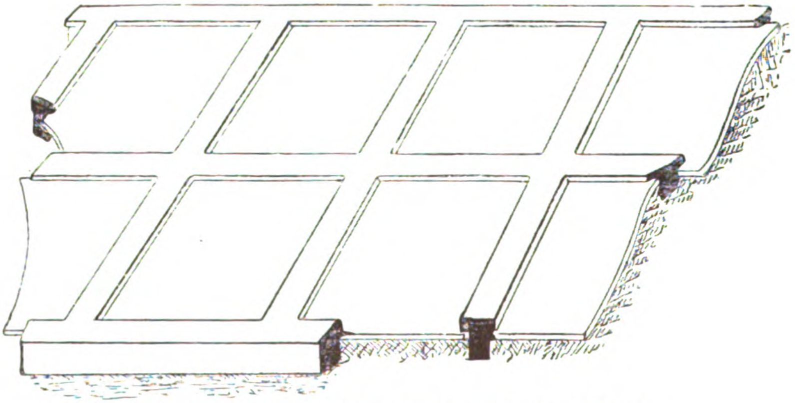


FIG. 1. A DE MURALT REINFORCED CONCRETE SLOPE FACING.

The following is a description of the principles upon which this class of slope defence work is carried out:

The cracking of the facing in consequence of frost or heat causing thrust from the soil underneath is obviated by dividing the slope facing into small separate sections, the reinforced concrete facing being no longer monolithic, as is usual, but consisting of a number of separate slabs kept in place by a system of beams, the whole being constructed *in situ* with an extremely small amount of plant or form-work.

Mr. de Muralt's principle of building the beams on the slabs, and not the slabs on the beams, thereby weighing down the slabs by the beams, is not only different to other reinforced concrete systems, but has great advantages in construction, being simple and easy.

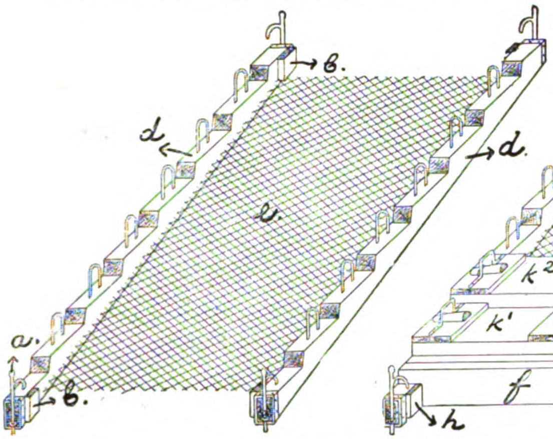


Fig. 3. Two Stepped Wooden Beams in Position with Expanded Metal Between.

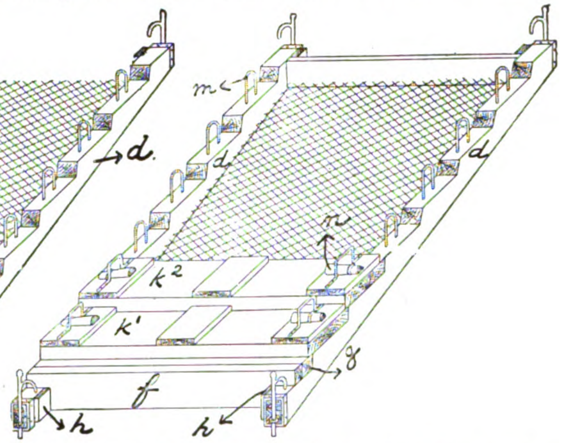


Fig. 4. Showing Two Lowest Steps Concreted and Covered by Boards.

Practically the whole of the concrete work can be done on the slope itself, very cheap and simple forms being utilised.

The division of the slope facing is the ruling idea of the system of construction, and this is obtained by building beams all round and resting on the slabs (*Fig.* 1).

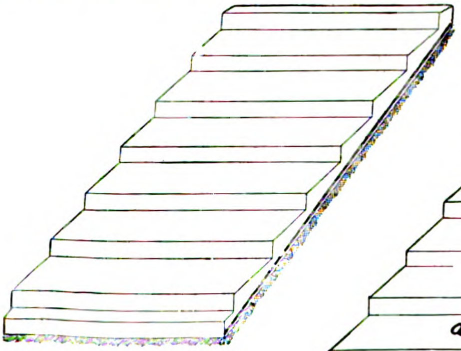


Fig. 5. A Slab Completed.

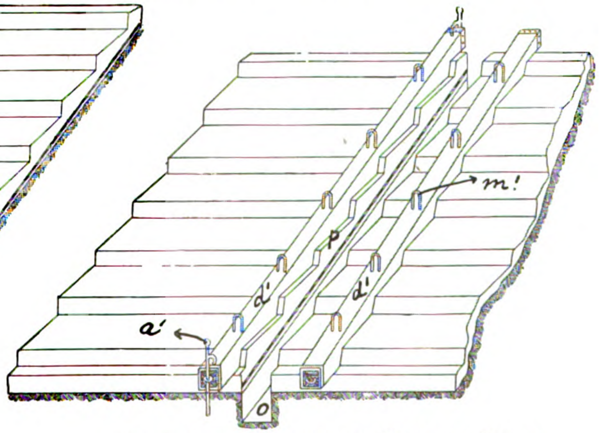


Fig. 6. Showing Trench and Forms for Sloping Reinforced Concrete Beams.

The soil of the slope first requires to be carefully graded. Where the soil is sand or clay, which does not permit of being cleanly and accurately graded level, straw is spread on the slope to a thickness of about 1 in., this straw being kept in place by means of straw-rope binders arranged in parallel lines at intervals of 7 in. to 8 in. Fig. 2 shows such application of straw to a clay slope. The layer of loose earth applied on the slope would otherwise certainly get mixed with the concrete during the ramming. In most cases the straw can be omitted.

After the slope is thus levelled, two notched or stepped wooden beams, 10 cm. by 12·5 cm., are laid parallel to each other at exactly 1·8 m. distance apart, extending vertically up the slope (*Fig.* 3). The length of these stepped beams *d* is 2·8 m., sufficient to allow a sheet of expanded metal measuring 1·8 m. by 2·4 m. to fit exactly between each pair of beams and the top and bottom boards *f* (shown in *Fig.* 4), these latter being 4 cm. thick and resting against cleats C (*Fig.* 3).

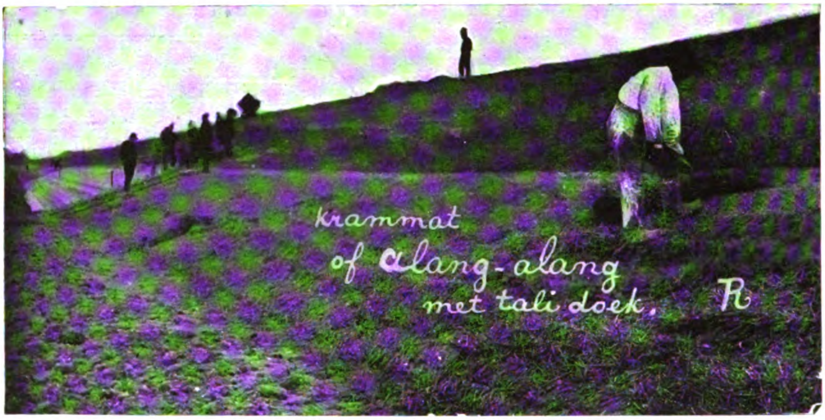


FIG. 2. STRAW MATTING LAID OVER LOOSE EARTH.

The beams *d* having been secured in position by iron stakes *a* (*Fig.* 3), a thin layer of concrete 2·5 cm. thick is laid on the slope, and on this a sheet of expanded metal No. 14 *e* is laid. Instead of expanded metal No. 14 a reinforcement of iron rods woven into meshwork can be used; but, needless to say, the greatest care must be exercised to see that the weaving is well done and the meshes truly formed; expanded metal is, however, cheaper and more reliable than iron rods. When the sheet of metal is in position, a board *f* (*Fig.* 4), with a fillet *g*, is placed between the beams *d* against the cleats *h* on the lowest steps of the notched beams. Boards are then placed on each step as the concreting is carried up the slope, they being retained in position by means of the iron handles *m* through which wedges *n* are driven. The concrete under the board k^1 is

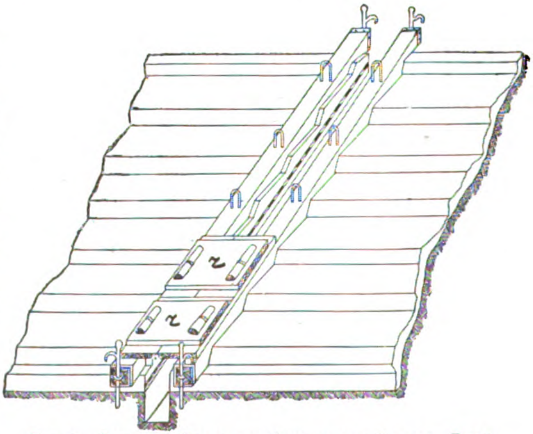


FIG. 7. SHOWING FORM FOR CONCRETING SLOPING BEAM.

carefully punned by means of iron rammers, the second step is then concreted, and so on until the whole slab is completed, step by step.

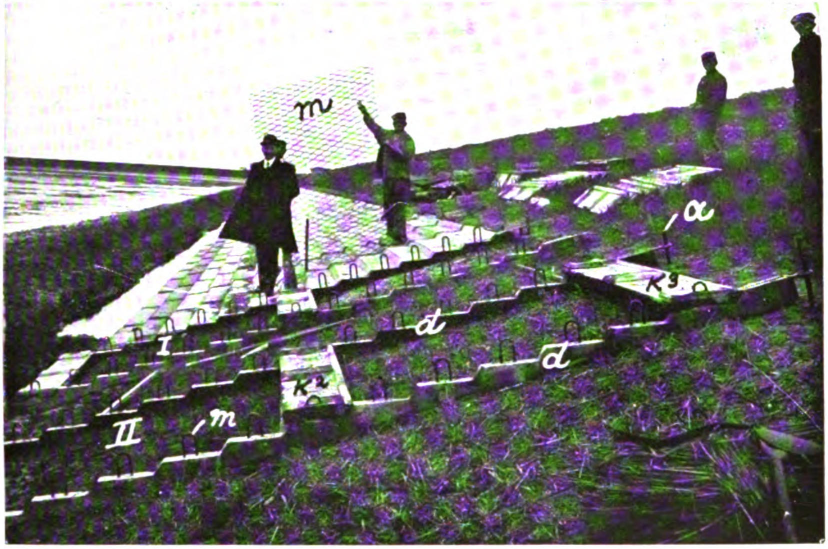


FIG. 6. LARGE WOODEN BEAMS LAID IN PLACE.

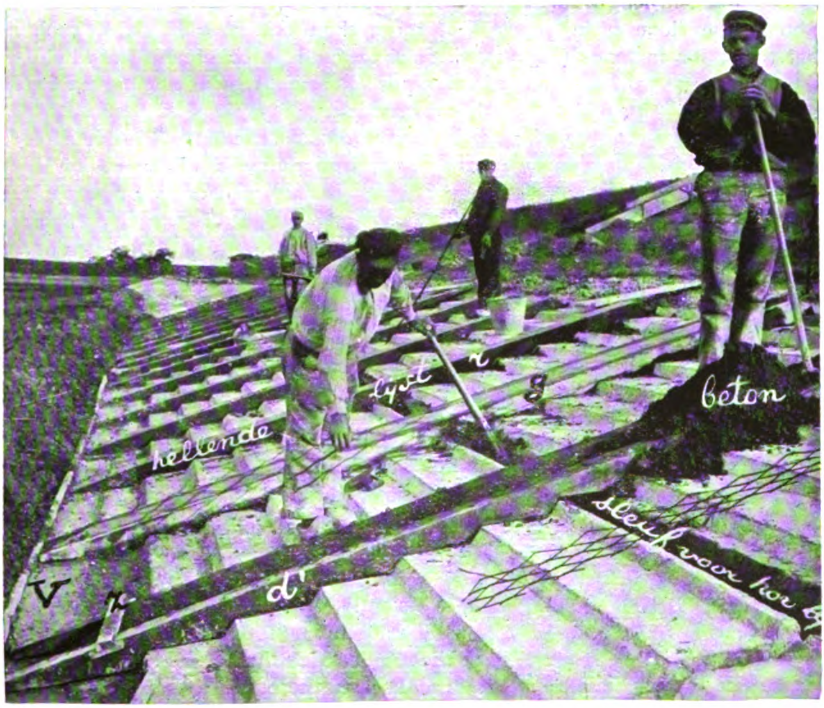


FIG. 8. CONSTRUCTION OF SLOPING FRAMING BEAMS.

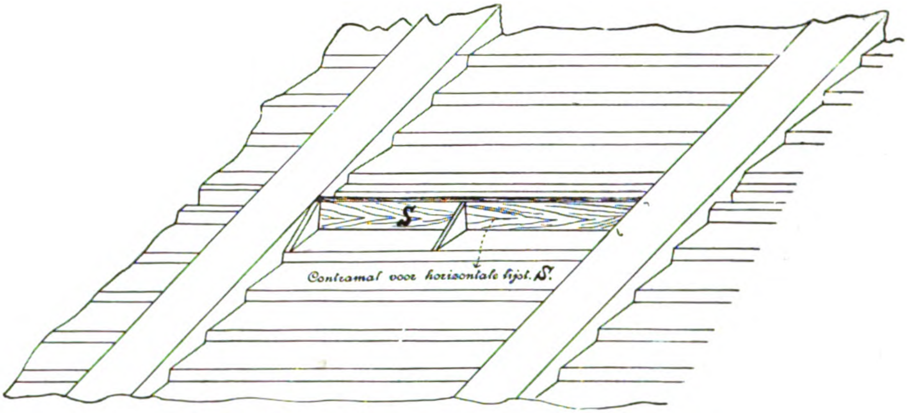


FIG. 9. FORM FOR HORIZONTAL REINFORCED CONCRETE BEAM.

If the work is done in fine weather, the forms can be removed a few minutes after concreting, but when the work of construction is below tide level, so that the work is submerged at high tide, the wooden forms should not be removed for twenty-four hours.

Fig. 5 shows a slab completed; it bears a strong resemblance to a flight of stairs, the thickness varying from 7·5 cm. to 12·5 cm.

The forms are all made of fir, and the iron stakes used to fix the beams in place measure 100 cm. in length and are nearly 1 in. in diameter.

Should the slope facing consist of more than one row of slabs, such as two parallel rows, for instance (*Fig.* 1), the slabs would be concreted the whole way up the slope between two long notched or stepped beams, the slabs being separated by a horizontal space. *Fig.* 6 shows such construction.

Fig. 6 shows a number of slabs in course of construction. Two sets of wooden beams *d* are fixed in position by means of the iron stakes *a*. Each set of large-sized beams *d* serves for the concrete of two slabs at a time. In order to keep the beams in place and the right distance apart, some of the covering boards—namely, the bottom one, the middle one (this covering at the same time two small boards, by which means the space required for the horizontal reinforced concrete beam is obtained), and the top board—are laid loosely on the handles *m* (compare also the boards, k^1, k^2, and k^3, shown in *Fig.* 4). Both panels between the beams in section 1 have already been given the first thin layer of concrete, and the workman is shown ready to lay the sheet of expanded metal reinforcement in the lower half.

FIG. 11. TRENCH FOR CONSTRUCTING HORIZONTAL BEAM.

As soon as the slabs have hardened sufficiently, trenches are dug all round the slabs to a depth of 15 cm. to 20 cm. below the underside thereof (*Fig.* 8). Iron rods are laid in these trenches so as to form continuous reinforcement quite independent of the slabs. The foot (*Fig.* 8) is first constructed, and against this the sloping wooden beams d^1 are then put up, being laid on top of the slabs, leaving open part p of the latter. These beams d^1 are also kept in position by means of iron stakes a^1, and measure 280 cm. by 10 cm. by 12·5 cm. The beams are also provided with handles m^1.

Fig. 7 shows the method of covering the facing slabs with boards r after the concreting is finished. If the slope is not steep and there are no tidal difficulties these boards can be left aside. The concrete must now be carefully smoothed and covered with straw or similar material to keep off the sun.

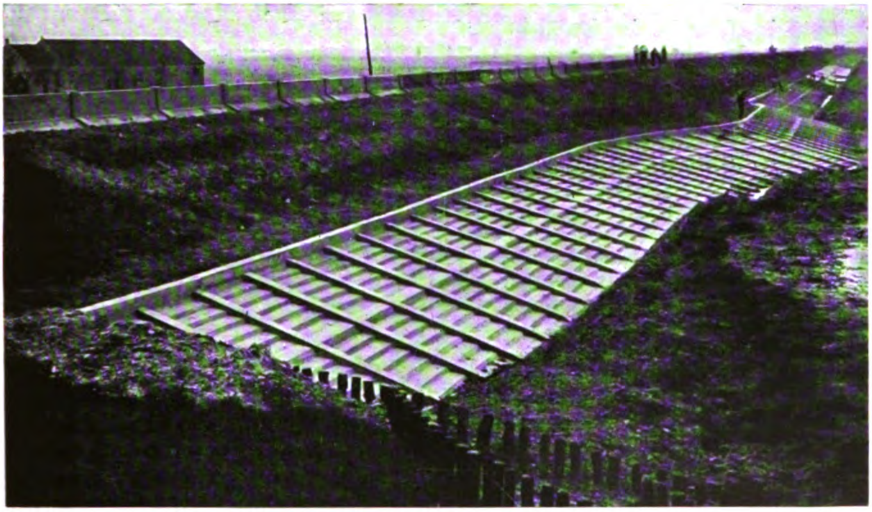


FIG. 12. REINFORCED CONCRETE SLOPE FACING IN ZONNEMAIRE, ZEELAND.
(Constructed under the supervision of H. Huisman.)

Fig. 8 shows how the beams d^1 are applied and kept in position by means of the tie-pieces Z. Near g the sloping concrete beam is shown still lying completed within its wooden forms, while further in the background they are shown totally finished.

Fig. 9 shows the method of constructing the horizontal reinforced concrete beams by means of the smaller wooden forms S, which are also shown in *Fig.* 10. *Fig.* 11

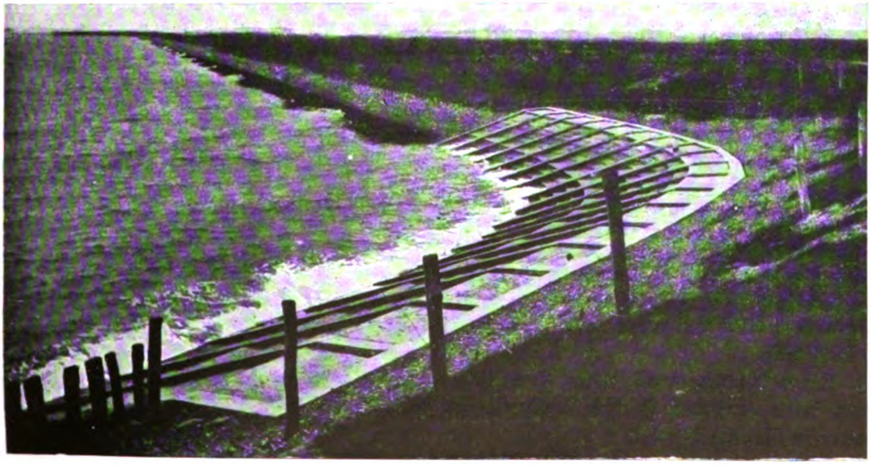


FIG. 14. ANOTHER VIEW OF THE FORESHORE DEFENCE WORK AT HALF-TIDE.

shows the space left between two slabs for the horizontal framing beams, as it is obtained by means of two small boards *pp*.

The reinforcement of the concrete framing beams, which are T-shaped, consists of iron bars $\frac{5}{16}$ in. dia. placed near the bottom or underside, and sheets of expanded metal No. 15, at the top in the head of the T, carefully cut to fit exactly between the wooden beams, thus reinforcing the parts that overlap the slabs. Such expanded metal reinforcements are shown being put in place in the forms in *Fig.* 8.

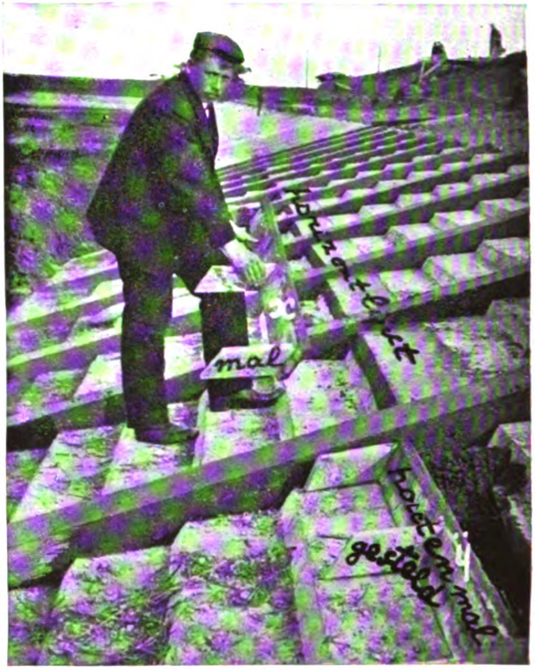


Fig. 10. Construction of Horizontal Framing Beams.

Immediately after the hardening of the concrete of the topmost beam the space behind is filled in with earth, and the completed slope is as shown in *Fig.* 12.

It should be borne in mind that the hardening of the slabs should have been continuing for some days before the construction of the steps can be commenced. Each time the edges, sides, and ends of the wooden forms should be well oiled to prevent the concrete sticking thereto.

All the slabs should be independent of one another and also of the framing. The reinforcing of the framing beams runs everywhere into one another at the junctions; therefore if one part of the framing should be raised, the total frame would rise and the slabs be left behind. The total mass of the framing of beams fixes the slabs on the slope, as its weight per sq. cm. is greater than that of the slabs. The foot of the facing needs to be carefully constructed and be watertight. When working on a sandy soil it is of the greatest importance to construct the footing before the slabs, in order to prevent the sand sliding down under the finished lower slabs under the action of water. It is also important when digging trenches in a sandy soil to thoroughly moisten the spaces left between the slabs before starting the work of trenching.

The De Muralt reinforced concrete slope-facing can also be applied on dry soil, with the use of only one wooden form for the construction of both slabs and framing beams.

Should the work be undertaken on the seashore, where the tide continuously washes the slope, more wooden forms are neccssary, because the slabs must remain covered during at least one tide, and the forms should be weighted with heavy rock to prevent them being washed away. *Fig.* 13 shows a reinforced concrete facing applied on a sea-wall whilst the water is low, and *Fig.* 14 shows the same facing with the water at half tide.

Since March, 1906, more than 80,000 sq. m. of reinforced concrete slope facing have been executed in the Netherlands, all on the now well-known principles laid down by Mr. de Muralt.

MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Question and reply in the House of Commons regarding Reinforced Concrete Buildings.—Mr. Horniman, M.P., recently put a question in the House of Commons on matters relating to reinforced concrete, to the First Commissioner of Works, who gave a formal reply. Question and reply explain themselves:

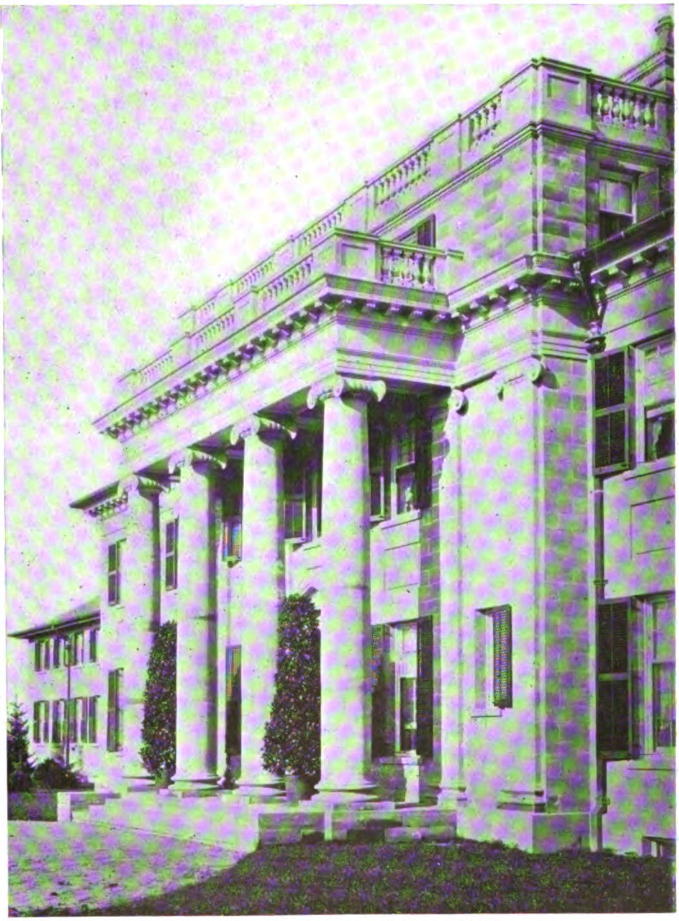
Question.

What the estimated life of buildings of reinforced or ferro-concrete might be, such as is now being used for the Post Office in the City; whether he has any report of how this kind of construction resists the effects of fire; and has he seen any reports or publications respecting the buildings so constructed after undergoing the test of fire at San Francisco?

Reply of the First Commissioner of Works.

That buildings of reinforced concrete are believed by experts to be at least as durable as those of brick or stone. That he had received a very valuable report confirming this opinion on the subject from the Joint Committee of the Royal Institute of British Architects. The experience of San Francisco, though interesting, is not of conclusive value, as the buildings there were subjected to earthquake fracture before the occurrence of fire.

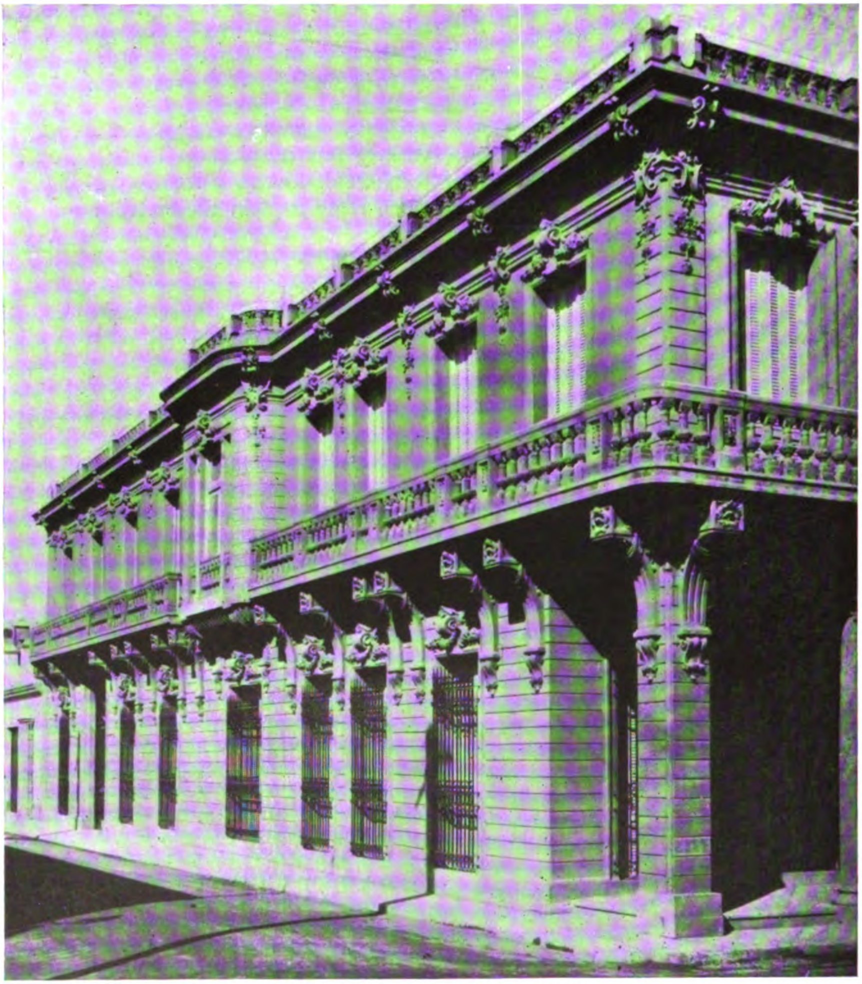
The Architectural Rendering of Concrete Buildings.—It has been sometimes pointed out to



Concrete Mansion at Port Chester, N.Y.
(Architects, Messrs. Carrere & Hastings, New York.)

us that it would be difficult to give buildings erected in concrete and concrete blocks an architectural finish that would be pleasing to the critical eye.

We, however, differ from this view, for we know of examples of concrete buildings of the highest architectural finish and general merit. We are also convinced that such buildings of concrete that have been pointed out to us as unsatisfactory in architectural treatment would have been equally unsatisfactory if carried out in the best of stones, or marble, or in terra-cotta. They are simply examples of the designer's ineptitude or his carelessness as to finish.



CONCRETE MANSION AT HAVANA, CUBA.
(Architect, Mr. Clement B. Brun, New York.)

We are presenting two examples of concrete buildings as to which there can be little complaint either in respect to design or finish, and they are both structures of some architectural pretensions.

One is a country mansion at Port Chester, N.Y. It was designed by Messrs.

Carrere & Hastings, the well-known architects of New York, and there is certainly nothing to cavil at in the design of this building.

The other example is also by a New York architect of standing—Mr. Clement B. Brun—and was executed at Havana, Cuba. In both cases, given good design, it is mainly a question of suitable finish, and in the Cuba example the exterior finish comprises a mixture of Portland cement and local stone powder, giving a clear grey tint to the building.

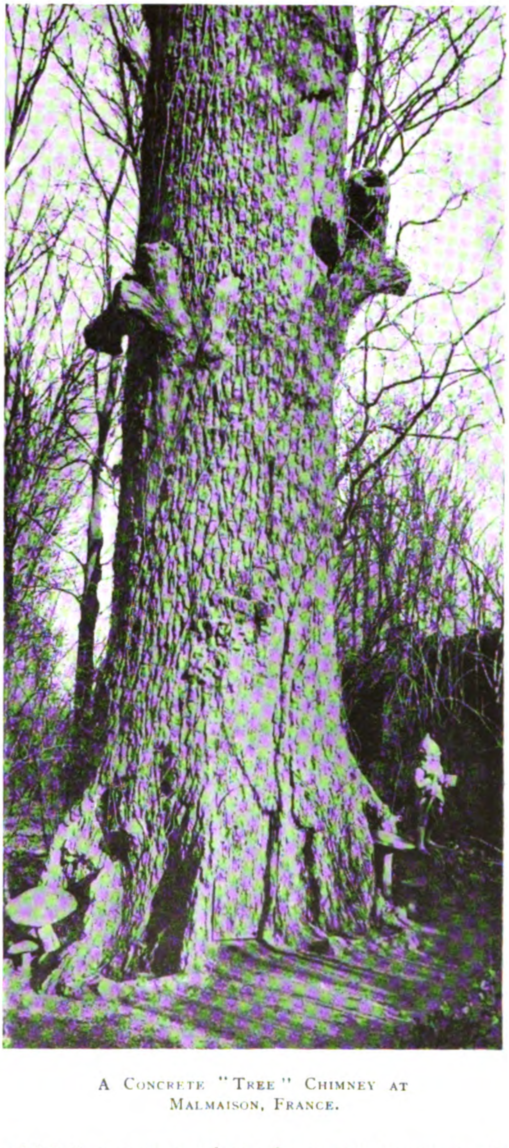
We present these examples with a view of showing what good work can be done in concrete, and are indebted for the illustrations to the *Concrete Review* and the *Cement Age* of America.

Concrete "Tree" Chimney.—One of the most novel applications of concrete yet known is to be found on the estate of Mr. Edward Tuck, at Malmaison, France, where the owner, being reluctant to spoil his timber by the erection of an ordinary chimney, devised a concrete tree in order that the harmony of the scene might not be disturbed. Concrete has been supplanting wood for a number of years, but this is probably the first instance where timber has been reproduced in this original form.

We are indebted to the *Cement Age* for our illustration.

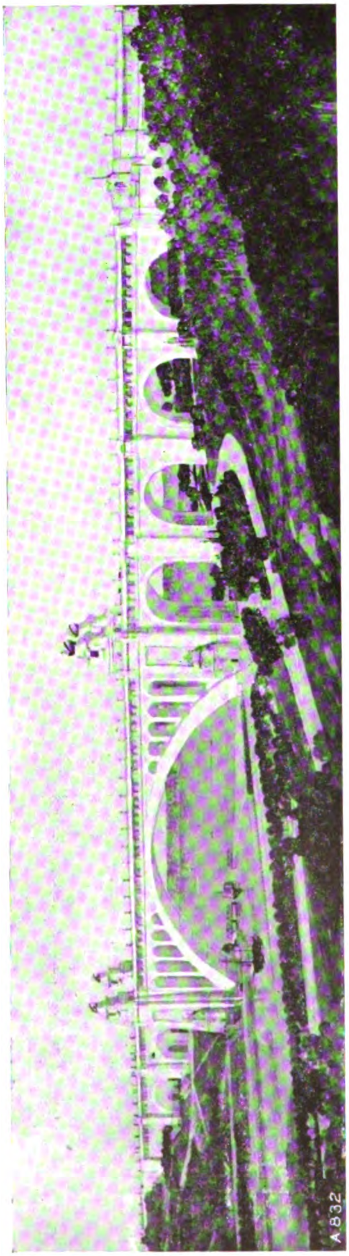
The Proposed Henry Hudson Memorial Bridge, Manhattan, N.Y.—The Henry Hudson Memorial Bridge is a reinforced concrete bridge, 2,840 ft. long. It has an upper and lower deck for surface and subway traffic; it has a 50 ft. roadway, two sidewalks of 15 ft. each, and four subway tracks. The subway tracks will not be installed until required in the future.

The approaches present no difficulties. The large engineering problems are encountered in the main arch, which has a span of 725 ft. centre to centre of skewbacks, and a rise of 177 ft. centre to centre. It exceeds in magnitude any masonry arch in existence, but its proportions are so chosen as to bring it within the limits of modern engineering practice.



A CONCRETE "TREE" CHIMNEY AT MALMAISON, FRANCE.

The arch rests on an immovable and imperishable foundation of hard rock 20 ft. below high water.



The Proposed Henry Hudson Memorial Bridge, Manhattan, N.Y.

In computing the stresses in the arch ring the most careful methods are used, and all reasonable possible causes of strain are taken into account. If computed by common methods the resulting stresses would be 80 per cent, of those provided for in this bridge.

The concrete of the arch rib is strengthened by embedded steel, well distributed. It will sustain compressive stresses only, no tension being possible. The concrete will have a least strength of 3,000 lbs. per sq. in. when three months old, and will grow in strength during many years.

The greatest allowed compressive stress on steel is 20,000 lbs. per sq. in., and on concrete 750 lbs. But this stress will come on the arch not before it is five years old, and the concrete eight times as strong. When four months old the concrete will be stressed to 350 lbs, ; when one year old to 535 lbs. ; when eighteen months old to 670 lbs. ; under a combination of worst conditions. At that time the concrete will have a compressive strength of 4,500 lbs. The greatest stress of 750 lbs. may occur only when the subway is operated and the concrete has reached the age of five years. The concrete will then be eight times as strong. The stresses in the arch will thus always remain within safe limits.

The bridge will be erected in falsework, designed and paid for directly by the Department. The arch rib will be kept at least four months on the falsework after completion and continually wetted.

The inspection should be thorough and up to date; simple facilities for testing and inspection should be provided.

The design and construction of the bridge is feasible and practicable, and if well executed will be successful.

We are indebted to Mr. Leon S. Moissieff, Department of Bridges, New York, for the foregoing information and the illustration.

Drilling in Concrete.— The drilling of bolt holes in partially green concrete is a tedious process (says a contemporary), owing largely to the frequent wedging of the drill. One contractor seems to have hit upon a simple method of drilling these holes without undergoing the delay incident to wedging. He uses a compressed-air drill hung in the guides of a small pile-driver frame, the drill occupying the same position as would the hammer in pile-driving. The drill is suspended by a wire rope, and raised or lowered by means of a hand windlass. One advantage of this arrangement is that a longer drill can be used than with the ordinary tripod outfit. A small metal pipe is carried with the drill into the hole, and through this water is forced under a heavy pressure, carrying off the chips, and thus preventing all tendency to wedge Many such holes have been bored in partially green concrete to a depth of over 6 ft.

Lectures.— Of the papers read during the last two months which dealt with the subject of concrete or reinforced concrete, one of the most interesting was by Sir Charles A. Nicholson, on the subject of the Jamaica earthquake and the rebuilding of Jamaica, in which reinforced concrete as a material for the reconstruction of the town buildings was strongly advocated.

Another recent paper of great interest was that read by Mr. William Muirhead, of Messrs. Muirhead & Co., London, before the Glasgow University Engineering Society, early in February, entitled "Some New Uses of Concrete." Mr. Muirhead pointed out to what a large number of new uses concrete has been put of late, both as simple concrete and reinforced concrete. The lecture was illustrated by examples, the slides showing how reinforced concrete can replace steel and iron, timber, masonry and brickwork in a most economical manner. Mr. Muirhead was of the opinion that research work was badly needed in this country to enable architects, engineers, etc., to design suitable structures in reinforced concrete.

Papers have also been recently presented before the Edinburgh Architectural Association and the Sheffield Society of Architects, on reinforced concrete, by Mr. M. Kahn.

CONTRACTS.

New Docks at Singapore.—The Registrar of Imports and Exports at Singapore reports that at a meeting of the Tanjong Pagar Dock Board the tender for the construction of a main wharf and lagoon dock by a well-known London firm of harbour engineers was accepted, the contract price being £998,700. The work will comprise 4.575 ft. of wharfage with a depth of 35 ft. at low-water mark, 20-ton blocks of concrete being used up to low-water mark, and above that massed concrete. The lagoon dock will have 3,800 ft. of wharfage with a depth of 30 ft. at low water in ordinary spring tides, the walls being composed of massed concrete.

Recent Contracts. — Of works on the Hennebique system that are being erected, outside bridges, docks and wharves, and what might be termed general engineering work, we are informed by Messrs. Mouchel and Partners, Ltd., that the system is being applied to a hospital and some polytechnic buildings in Liverpool, school buildings in Petersfield, seven factory buildings in London, Leeds, Newcastle, Blackburn, Hull, Elland and Luddendenfoot, for warehouse buildings in Glasgow, Nuneaton, Portsmouth and Cowes, a marine laboratory in Newcastle, and a football stand at Liverpool. A considerable amount of foundations for buildings is now being erected on the Hennebique system.

Special mention should be made of a floor on the Hennebique system in a very beautiful mansion erected by Messrs. Holloway Bros. at the corner of North Audley Street and Upper Brook Street, London, of which Messrs. Read and McDonald acted as architects, and also in a new three-storey building for Messrs. Reckitt & Sons at their Stoneferry Works, Hull, for which Mr. Willett was the architect, and the work was executed by the Yorkshire Hennebique Contracting Co., Ltd., of Leeds.

Messrs. W. Cubitt & Co.—The general contract for the new premises for the Bank of England at Priory Lane, Roehampton, has been awarded to Messrs. W. Cubitt & Co., as also the contract for the reinforced concrete work.

Messrs. D. G. Somerville and Co., of Victoria Street, S.W., have secured the contract for the whole of the reinforced concrete flooring, with all the reinforced concrete clothing to the structural steelwork, for the new premises for the Norwich Union Insurance Co. at the corner of St. James's Street and Piccadilly. The architects are Messrs. Runtz & Ford.

In addition, they have secured contracts for the supply and erection of the steel roofing for Messrs. Edison & Swan's extension at Ponder's End; reinforced concrete floors, beams, stanchions and roofs for Messrs. Carwardine's flour mills in Kingsland Road, and the construction in reinforced concrete of curved roofs, domes and floors for St. Charles' College Chapel, Notting Hill, for which Messrs. Lamb & North are the architects.

The Considère Construction Co.—We are pleased to notice that the Great Eastern Railway Co. have decided to construct the road bridges over their line at Angel Road, Tottenham, in reinforced concrete, and that the Considère system has been adopted by Mr. J. Wilson, M.Inst.C.E., the chief engineer to the Railway Co.

The design comprises 17 equal spans of 42 ft. 9 in. each. Spiralled reinforcement is employed in the columns and in the continuous beams over supports.

We hope in a future issue to give some detailed particulars of this interesting example.

The contractors for the work are Messrs. Anthony Fasey & Son, Leytonstone.

Amongst other works on the Considère system now being carried out in this country, we note an important one at Thames Haven, where a jetty head in 45 ft. of water is being reconstructed.

CATALOGUES.

The Yorkshire Hennebique Contracting Co., Ltd.—We have received an exceedingly well-prepared catalogue from the Yorkshire Hennebique Contracting Co., Ltd., presenting views of works executing by this firm in reinforced concrete.

The catalogue is a bulky one and is eminently descriptive of the many uses to which reinforced concrete can be put.

Of the various illustrations we think those showing the extension of the floor at the Waterloo Mills, Bradford, the floors being supported by reinforced concrete cantilevers. is perhaps the most interesting as far as constructional work above ground is concerned, whilst of the engineering works illustrated the 7-ft. diameter sewer pipe for the River Rea improvements for the Birmingham Corporation, and several other works in connection with these River Rea improvements, call for special attention.

Of the many minor uses to which reinforced concrete can be economically put, we observe several water towers for the North-Eastern Railway, and for the Pocklington Urban District Council.

The Booklet is certainly one that speaks largely for the advancement of Reinforced Concrete in Great Britain.

The United Kingdom Fireproofing Co., Ltd., send us an excellently-printed booklet describing the different floor systems it favours in the execution of contracts. One of these might be styled a pure hollow reinforced concrete system, comprising a number of tubular slabs supported by light reinforced concrete channels. Another we might term a composite floor, in which the reinforcement to the concrete slabs is supported with the aid of stirrups from the principal girders. A useful example is illustrated in the Royal Manchester Infirmary.

We hope to deal with this system of floors more fully on a future occasion, with some illustrations.

The Lehigh Car, Wheel and Axle Co., of Catasauqua, send us a large catalogue illustrating their Pulverizer Mill, which is an excellent example of the best American printing, illustrated in a thorough manner with diagrammatic drawings and photographs. There is no doubt that this form of Pulverizer is making considerable headway in Europe, and the attention of those interested in the subject should be called to this catalogue as being most clearly descriptive of the principles on which the apparatus is worked.

The Century Cement Machine Co., Rochester, U.S.A.—A most practical and at the same time charming catalogue has been received from the Century Cement Machine Co., of Rochester, U.S.A., confined entirely to their "Hercules" concrete block making machinery. Concrete block making is still in its infancy in this country, but those who are considering the question of introducing this form of construction would do well to obtain the catalogue in question, which, apart from dealing with the particular application under review, gives a considerable amount of general practical information.

The Cruciform Reinforced Concrete Co., of London, have sent us particulars of their reinforced telegraph poles, which we hope to deal with at greater length in a future issue. Provision is made by means of wood plugs inserted in the concrete for fixing the cross bars for carrying the wires, also for the steps for ascending the pole, and for the lightning conductor. These telegraph poles have been made up to 36 ft. long in moulds, but in the case of the longer poles up to 70 ft. long, it is intended to build them *in situ*, and for this purpose a telescopic ladder tower has been designed.

The Sideolith Co. send a catalogue showing their method of skeleton steel reinforcement, which claims attention.

TESTS

Reinforced Concrete Tests.—An interesting test was carried out on Tuesday last by the Improved Construction Co. at Messrs. David Kirkaldy & Son's testing and experimenting works in Southwark Street. The principal test was the subjecting of a reinforced concrete beam 16 ft. 6 in. long by 13·5 in. deep by 10 in. wide, and containing 30 per cent. of metal, to a concentrated pressure of over 17 tons. Some tests were also made with reinforced concrete stanchions.

NEW USES FOR CONCRETE

AT HOME AND ABROAD.

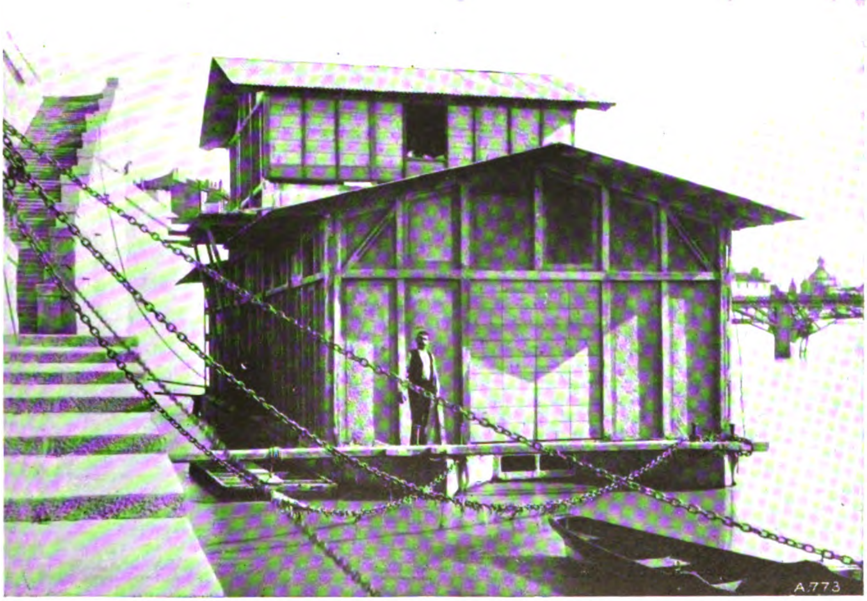
Under this heading reliable information will be presented as to new uses to which concrete and reinforced concrete are put, with data as to experience obtained during the experimental stage of such new applications of these materials. The use of reinforced concrete as a substitute for timber in exposed positions is one of the questions of the moment. Railway sleepers, telegraph posts, fence posts, etc., of concrete are being tried. Similarly, efforts are at present being made to prove that reinforced concrete is an excellent substitute for brickwork, where structures of great height are required.—ED.

REINFORCED CONCRETE BARGES AND PONTOONS.

WE have pleasure in reproducing some interesting photographs of barges and pontoons constructed on the Tiber by Messrs. Gabellini, of Rome.

Barges and pontoons built in reinforced concrete are advantageous, inasmuch as they are quickly constructed, the construction is simpler, and the cost in comparison to ordinary methods of construction considerably less.

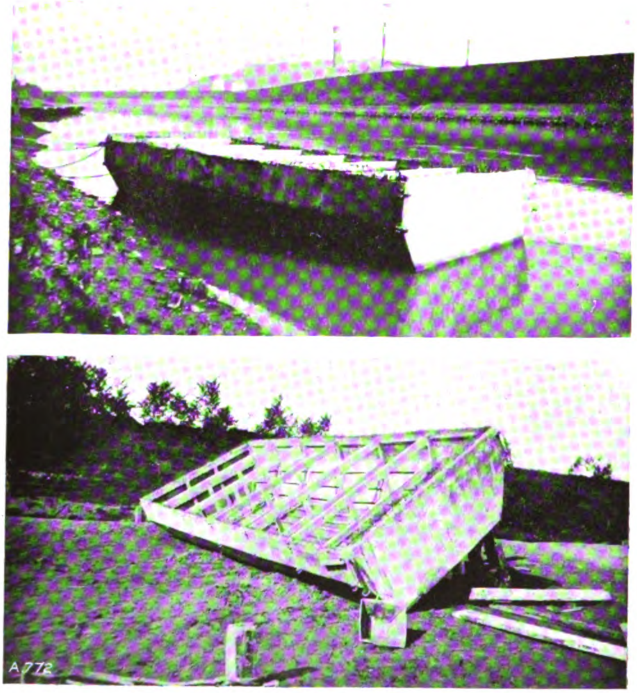
The monolithic character of the construction gives higher powers of resistance for the rough usage these vessels get, and generally enables them to stand exceptional strain. Then there is the additional advantage of protection from fire, as compared with vessels constructed of wood. They also offer but slight resistance to the water, owing to their smooth surface, and the fact that seaweed cannot so easily adhere. The usual scraping is quickly and easily done, and any necessary repairs are executed without much difficulty, as some filling in with concrete or cementing generally suffices.



FLOATING "CHALET" FOR THE ROME ROWING CLUB ON REINFORCED CONCRETE PONTOONS.

It has been calculated that the cost of construction as compared with steel barges or pontoons is about one half, and the cost of maintenance about a fourth or third.

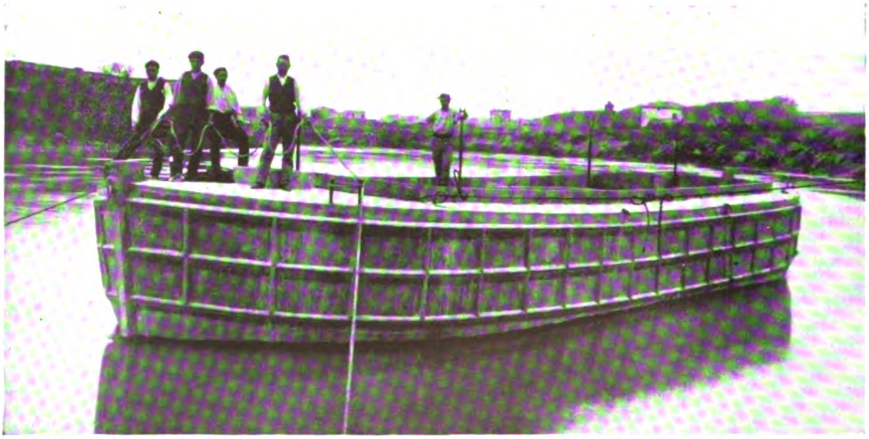
Referring to our illustrations, the floating "chalet" for the Rome Rowing Club was constructed in 1897 on pontoons, and has a length of 67 ft. with a beam of 21 ft. The posts and roof are of concrete, reinforced with expanded metal.



Reinforced Concrete Pontoons for the Rome Rowing Club.

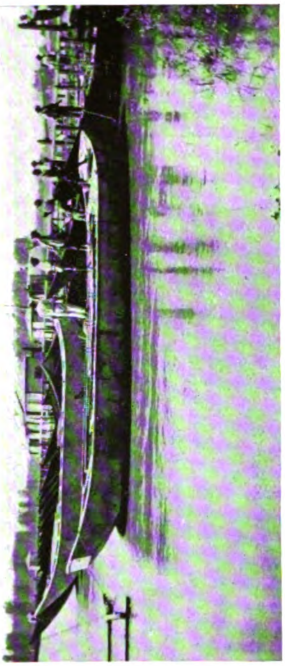
The "Liguria" is a barge of 150 tons, and was constructed by Messrs. Gabellini in 1905. Since January, 1906, she has been working in the harbour of Civita Vecchia, near Rome. In October, 1905, she was towed from Rome down the Tiber to the sea. She was also towed to Genoa and Savona, after which she was towed back again to Genoa and Civita Vecchia.

The 100-ton barge we illustrate was constructed to the order of the Italian Government in 1906. She was tested in the military harbour of Spezia, and was so successful that a contract was placed for four more barges on the same lines. These par-

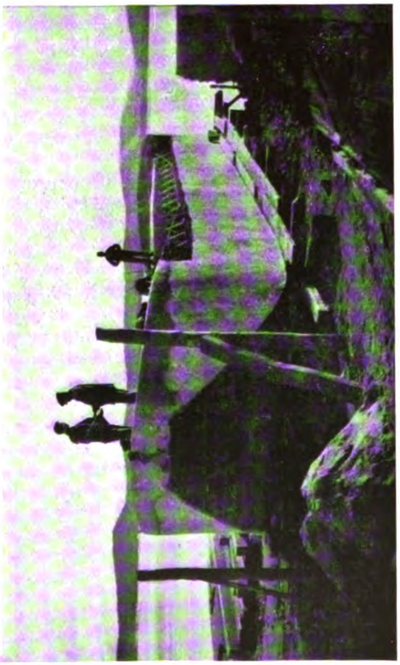


A 100 ton Reinforced Concrete Government Barge.

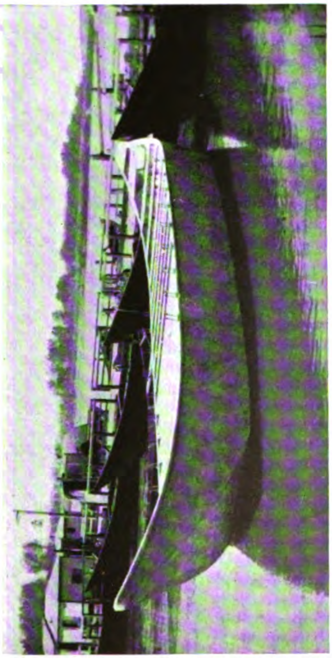
ticular barges have a double shell forming watertight compartments, and are practically unsinkable. Their dimensions are 51 ft. length and 16 ft. beam.



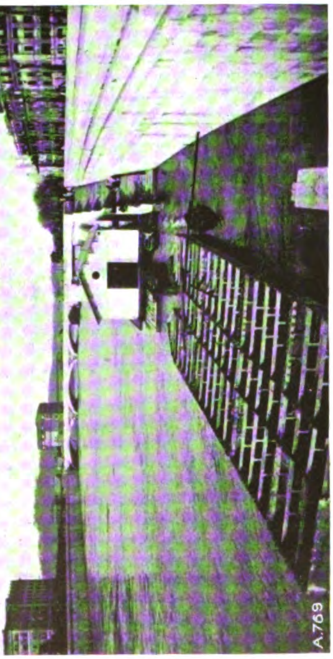
Two of a series of 60 reinforced concrete pontoons for a floating bridge. Length, 42 ft.; beam, 14 ft.



Heavy reinforced concrete pontoon, in course of construction.



Small reinforced concrete pontoons on the River Po for a floating bridge near Pavia.



One of eight 50-ton "rafts" for Eirrawova (Sardinia) Harbour. Length, 45 ft.; beam, 14 ft.

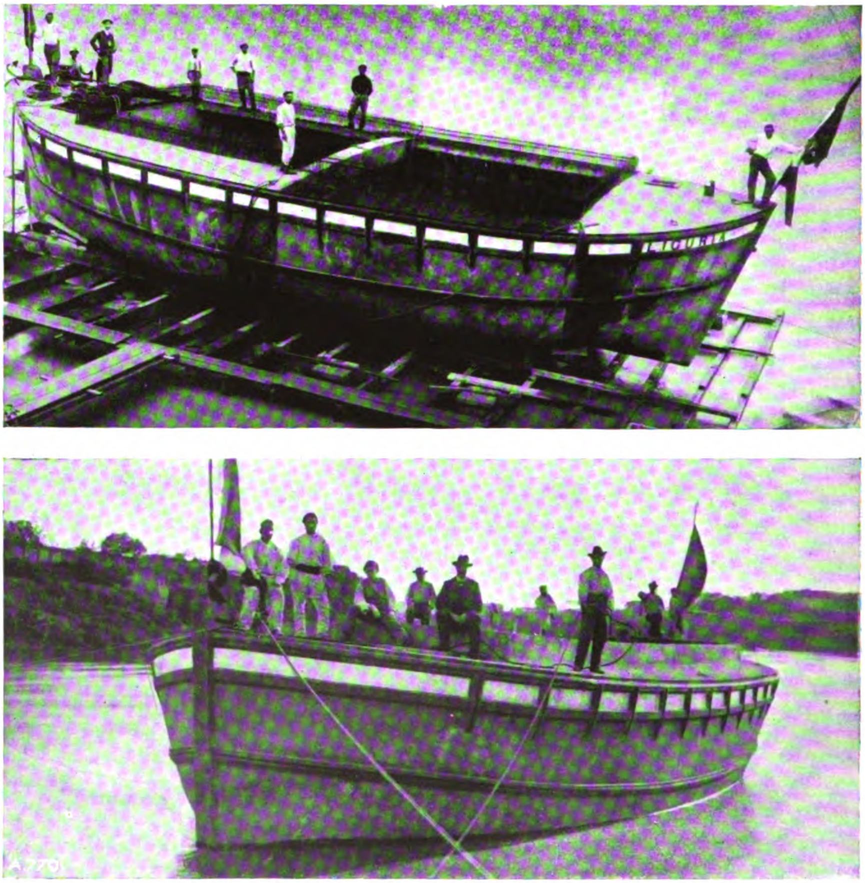
We also illustrate a number of smaller pontoons, which are built in large numbers.

This form of construction merits the immediate attention of some of our Government Departments at home, and more particularly the attention of our Indian P.W.D. officers and some of our Colonial authorities.

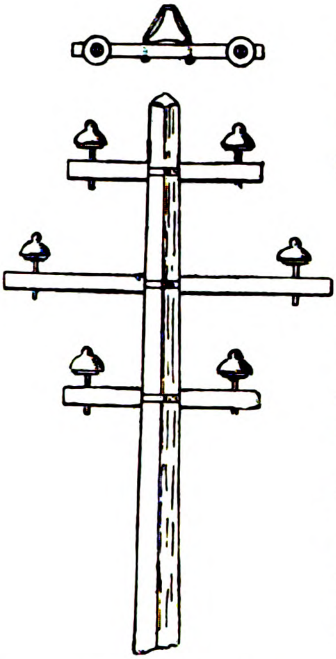
We are indebted for our illustrations and information to Messrs. Gabellini.

TELEGRAPH POLES IN REINFORCED CONCRETE.

As dealt with at some length in our preceding issue a new application of reinforced concrete has been found in the construction of poles for carrying telegraph wires or wires for conveying current for electric railways, etc. The annexed figures illustrate the construction adopted by the Brescia Construction Co., of Brescia. The poles are from 26 ft. to 33 ft. high, and have to resist a horizontal tension of upwards of 1,200 lbs. at the summit. The new poles cost less than corresponding iron poles, and do not necessitate painting. They have also no external conducting material, and are unclimbable, the workmen being provided with a simple attachment for climbing when required.



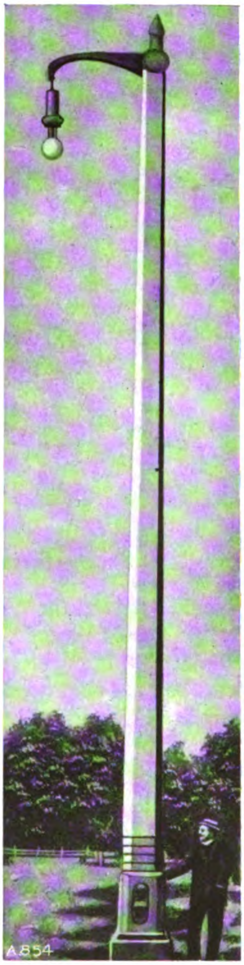
The "Liguria" (Reinforced Concrete Barge ready to launch and after taking the water, constructed in 1905. 57 ft. length, 18 ft. beam).



The construction is clear from the illustrations, and it will be seen that the arrangement of the concrete and the reinforcement is such as to give a maximum of resistance with the use of a minimum of materials.

REINFORCED CONCRETE ELECTRIC LIGHT STANDARDS.

We also take the opportunity of presenting an illustration of an electric light standard of architectural pretensions, to be found in Hungary, the standard being entirely constructed of reinforced concrete.



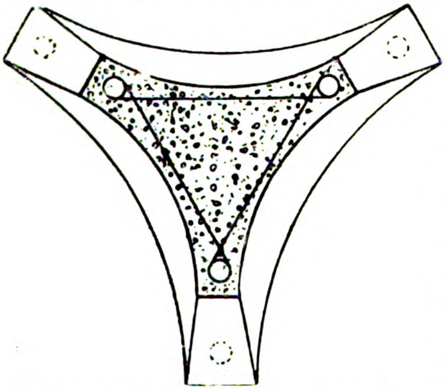
A Reinforced Concrete Electric Light Standard in Hungary.

REINFORCED CONCRETE FOR STATION PLATFORMS.

We are indebted to the *Engineering Review* of London for the illustration which we show of a reinforced concrete platform and fence, constructed on the Brighton Beach Line, Brooklyn, N.Y.

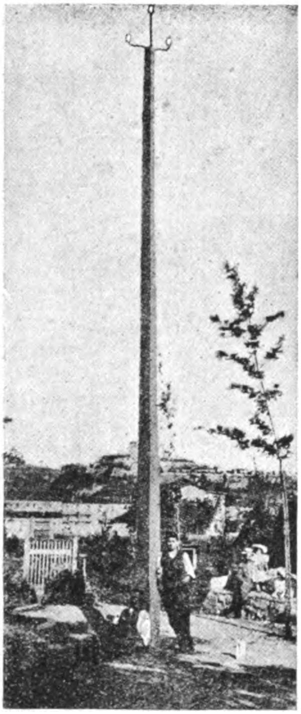
The platforms are of reinforced concrete slabs, carried by beams and girders of the same material, and are covered with a granolithic finish. The fences run the whole length of the platforms, and consist of Portland cement plaster reinforced by a metal lath of No. 28 gauge, having a cross section of 0·18 sq. in. per ft. of width and weighing 67 lbs. per 100 sq. ft. The lath is 1 in. high, the minimum plaster thickness covering the metal on each side being $\frac{1}{2}$ in.

The lath is carried in continuous sheets through the whole length of the fence, and is not broken at the posts. The latter which are on 10 ft. centres are reinforced with four $\frac{1}{2}$ in. rods set deep into the concrete platform. The rail is reinforced by two $\frac{3}{8}$ in. rods running longitudinally, and by a strip of lath laid horizontally.



Reinforced Concrete Telegraph Poles in Italy.

The platforms were completely cast before the fences were started, and the rods for the posts were set when the platforms were built. In constructing the fences the lath was held in place by studding of 1 in. angles supported by braces. The concrete was then put on from the side opposite the



REINFORCED TELEGRAPH POLES IN ITALY.

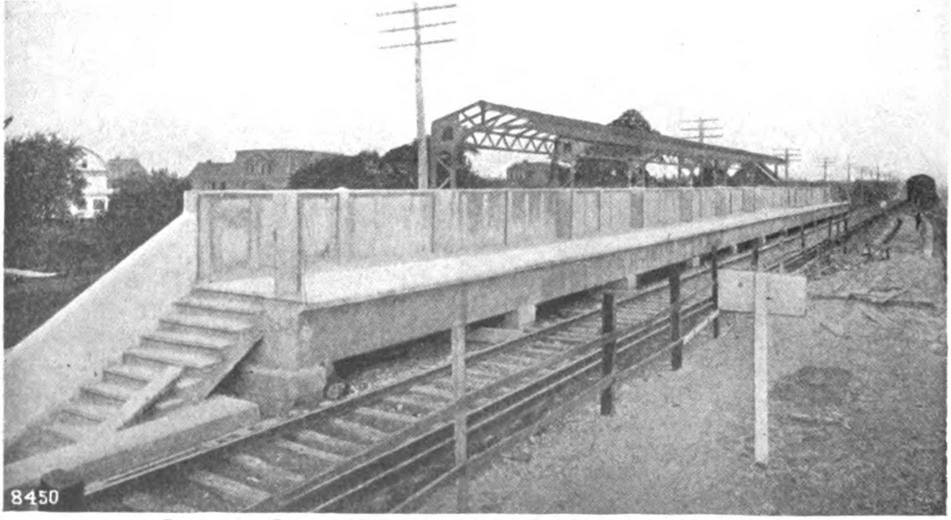
studding, and after it had set the studding and braces were removed and the other side was finished. The concrete was made of 1 part Portland cement and 2 parts sand.

CEMENT WINE TANKS.

Cement wine tanks are extensively used in Algeria, and are rapidly superseding all others. The tanks, called locally "amphores," are in cement on a metal frame, generally steel, and are glass lined. One house in Algiers has made a specialty of the construction of complete plants in reinforced cement, and may be said to have the monopoly of the business, not only in Algeria and in Tunis, but also in the south of France and in many Mediterranean countries, including Palestine, where a plant for 30,000 hectolitres (1 hectolitre equal to 26·417 gallons) has been constructed.

REINFORCED CONCRETE FOR WARSHIPS.

An Italian correspondent writes that at a meeting of naval and mechanical engineers held in Genoa on January 18, Signor L. d'Adda, an Italian naval engineer, lectured on a proposal to protect large armour ships with reinforced concrete instead of steel plates. He said that this system had been used with excellent results for land fortifications. While following the operations of the Russo-Japanese War in the Far East and near Port Arthur, he had been impressed by the resistance offered by Japanese casemates, which were thus protected, against heavy projectiles. The weight of such plates would be about the same, and the space required was not more than with metal armour, while the cost would be substantially less. The Ministry of Marine has directed that some of this concrete protection shall be exhaustively tried at the Muggiano. The results are being awaited with interest in Italian naval circles, and we hope to publish further information on this subject.



REINFORCED CONCRETE PLATFORM AND FENCE AT BROOKLYN, N.Y., U.S.A.

NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

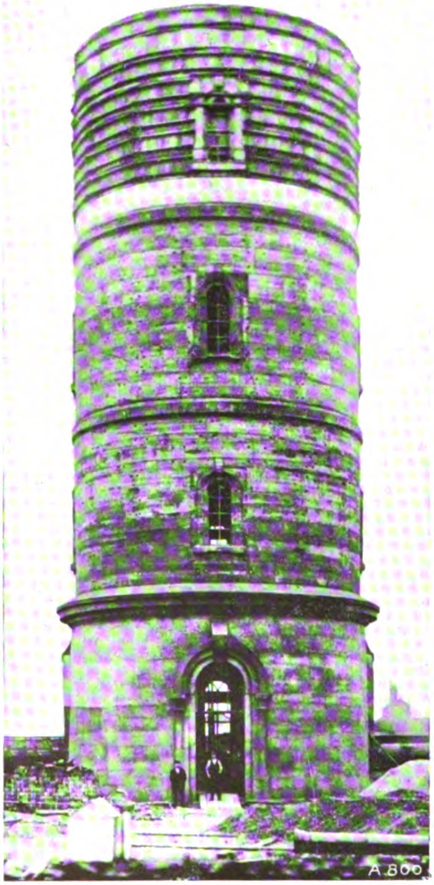
RECENT BRITISH EXAMPLES OF REINFORCED CONCRETE.

The Cleethorpes Reinforced Concrete Water Tower, Lincolnshire.

WITH our conservatism and the difficulty which attends the efforts of those who are willing to champion the introduction of things apparently better, but new and untried, it is refreshing and encouraging to happen upon some who have the courage of their convictions, to examine and test the merits of any such as appear to offer a material advancement in the world's work.

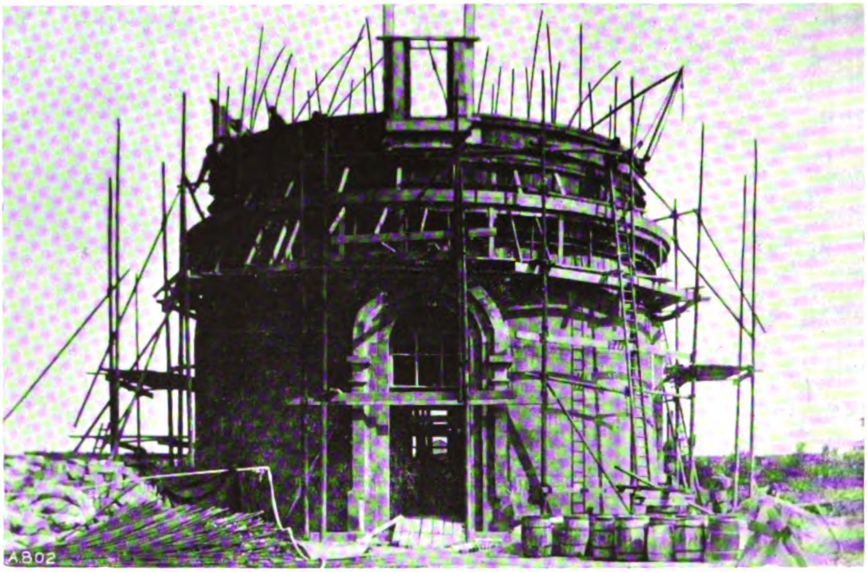
The subject of these notes we should consider as one such case, in which the application of reinforced concrete in the construction of a water tower is probably unique as regards height, capacity, and constructive details.

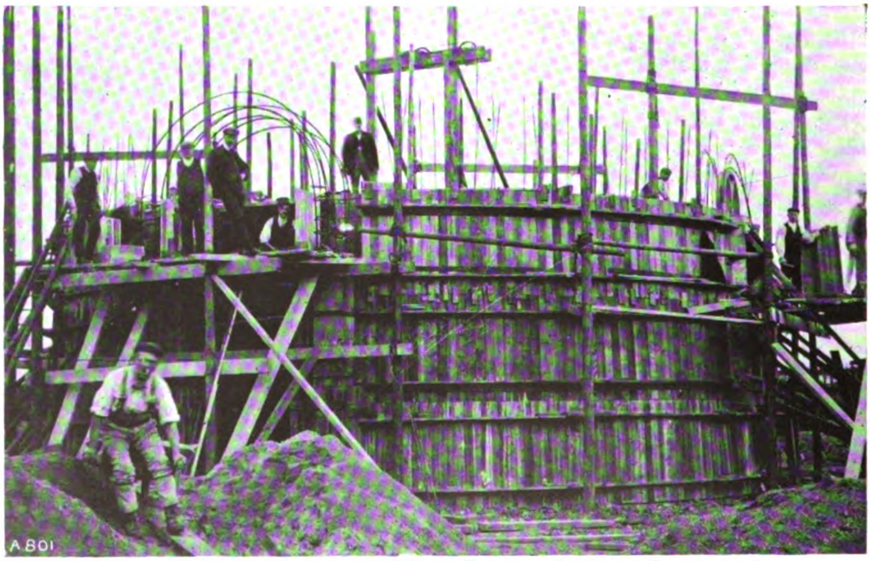
The problem in this special case was, in the absence of any natural elevation, to provide an ample water storage as a stand-by, and to tide over any period of excessive drought or the effect of fire, frost, etc., this necessarily at a sufficient elevation to give the requisite pressure to maintain a constant and uniform supply over a district of varied elevations and fluctuating consumption, which at times may be liable to be a tax upon the power of the pumping machinery to an undesirable extent. It was also to ensure a certain supply of water in the event of breakdowns, stoppages for repairs of machinery, or any unforeseen circumstances that may affect the source, which is from artesian borings, the water being distributed by means of powerful pumping plant direct into the mains, the community being at present entirely dependent upon this system.



THE CLEETHORPES REINFORCED CONCRETE WATER TOWER.

The Great Grimsby Waterworks Co., represented by their engineer, Mr. H. Hewins, having considered this matter in all its details, eventually decided that, as regards cheapness, facility of construction, and general endurance and stability of structure, a concrete tower, reinforced with "Indented Bars," in accordance with the designs prepared by him in conjunction with the Patent Indented Steel Bar Co., was the most suitable for the purpose, and operations were commenced in June, 1907.

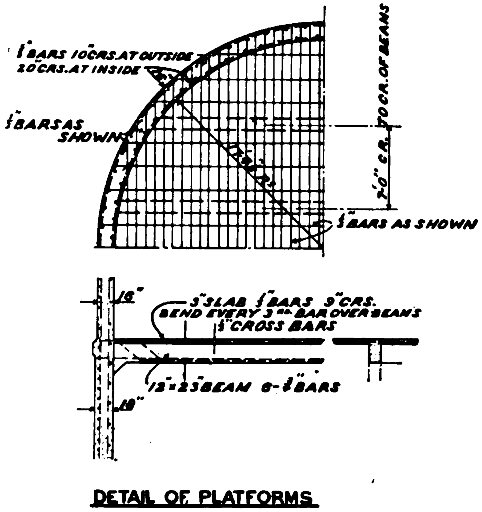




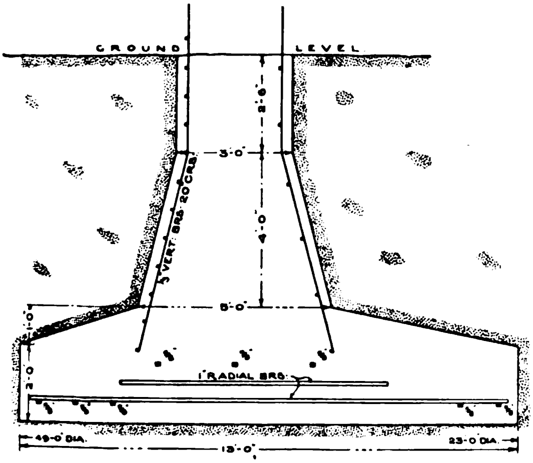
Cleethorpes Reinforced Concrete Water Tower in Course of Construction.

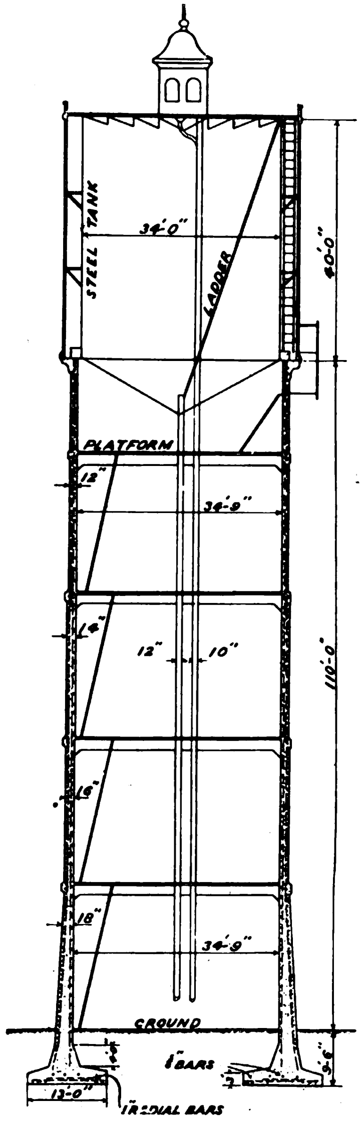
The site of this tower had to be carefully considered, owing to the great weight which would have to be supported; consequently special care was taken in designing the foundations, avoiding the costly process of piling and yet ensuring against any possible chance of subsidence.

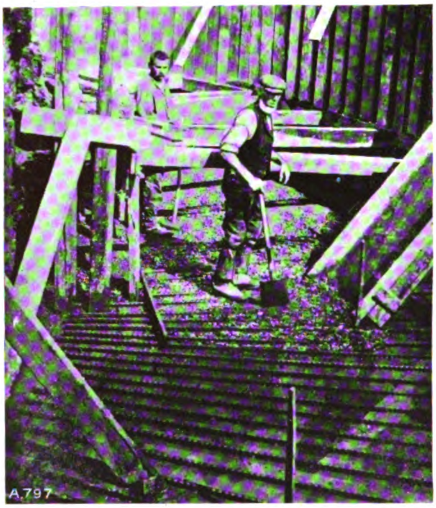
The top excavation, for a depth of 8 ft. 6 in., proved to be of a soft loamy nature, broken by bands of pure sand; but at this depth a bed of boulder clay, extending to the chalk rock, was struck. From the records of borings made, it was considered uniform throughout, and safe to carry the structure, but the excavation was continued down for a further depth of 12 in.



The Cleethorpes Water Tower.
Details of construction above and below ground.





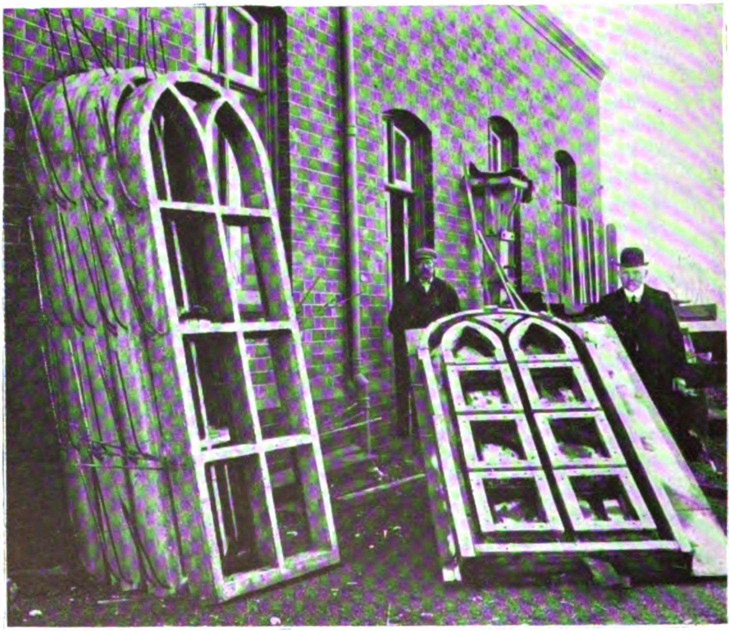


Cleethorpes Water Tower.
(Showing "Indented" Bars laid ready.)

A test was then made to ascertain the capacity of the boulder clay to bear the heavy weight which it was proposed to place upon it, and this was done by means of constructing a timber platform supported upon four timber legs, each leg being 12 in. square and resting upon the trench bottom. The load was gradually applied by means of building up a stack of loose bricks, and eventually a pressure of $5\frac{1}{4}$ tons per sq. ft. was applied without any appreciable sinking of the legs. These results were considered—taken in conjunction with a reinforced concrete foundation—quite satisfactory, and the work of concreting was commenced and continued in accordance with the design and section showing work below ground level.

The reinforcement below ground level consists of two systems of 1 in. radial bars, spaced 8 in. apart, centre to centre, with $\frac{5}{8}$ in. annular rings, as shown. The bars for the commencement of the general scheme of reinforcement for the whole tower are of 73 in. verticals, spaced 20 in., centre to centre, and $\frac{5}{8}$ in. annular rings, spaced 9 in., centre to centre.

The detailed section, as illustrated, shows the general scheme above ground level, and the illustrations of completed work show the mouldings and architectural finish which it is possible to embody in a reinforced concrete structure. This feature is rather worthy of notice, as so many people are inclined to think that reinforced concrete structures must necessarily be crude and ugly, and only fit for utilitarian purposes.

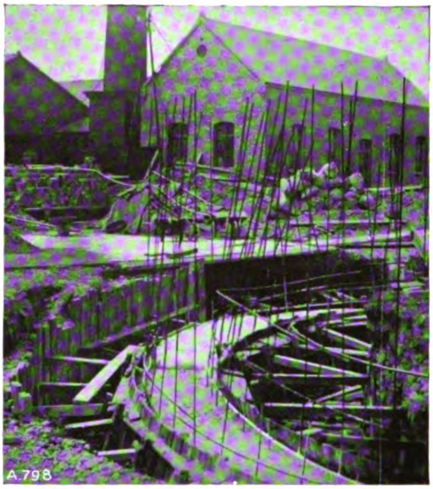


Cleethorpes Water Tower.
(Reinforced Concrete Window Frames.)

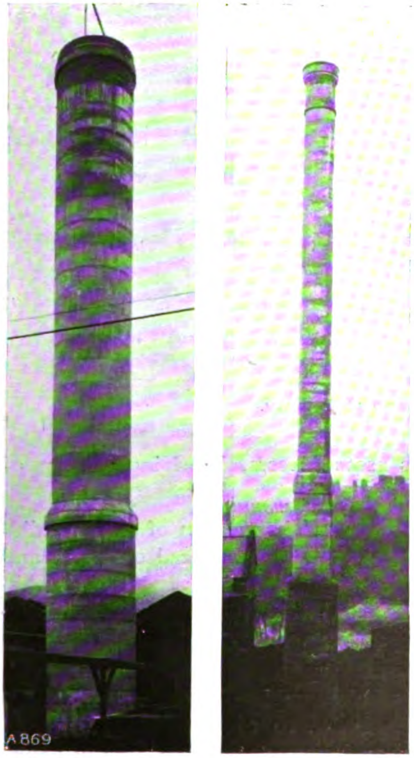
The process of construction in this reinforced concrete work was so uniform and simple that, whilst it enabled work to be executed at a price and under conditions which otherwise would not be possible, so that there is very little in the way of difficulties or inconvenient circumstances during the process of construction to record, yet a few facts may perhaps be interesting, such as the following:—

The area of foundations is 1,470 sq. ft., and the total weight to be borne about 3,000 tons, giving a total dead-weight pressure of approximately 2 tons per sq. ft.; this is liable at any time to be further increased under certain conditions of wind pressure.

The concrete for all the work below third floor is composed of cement, carefully selected, sand, and clean gravel, in the proportions 1 : 2 : 5; and for the work above, 1 : $1\frac{1}{2}$: $3\frac{3}{4}$.



Cleethorpes Water Tower.
(Showing reinforcement.)



Reinforced Concrete Chimneys.

The Cape Copper Co's Chimney, Briton Ferry. Messrs. Greeves' Chimney, Belfast.

The whole reinforcement is carried out with "indented bars," used in their natural state except for a few simple bending operations, which were easily accomplished on the work.

The windows and doors were cast on the ground, and afterwards lifted into position and built and tied with suitable reinforcement into the mass concrete of tower.

In the illustration of windows the reinforcing bar ends will be seen projecting from the sides; these ends are built into the mass concrete of tower, and provide a continuous bond or tie to the walls on each side of window, and so around the complete circumference of the tower.

It is also intended to construct the entrance door of concrete, reinforced with bars, and the fair edges formed of channel irons, these being suitably tied into the concrete.

Provision for powerful engines and pumps for filling the tank are included in the scheme, also automatic indicators, lift, etc.

We are indebted for the foregoing information, and for the illustrations, to the Patent Indented Steel Bar Co., Ltd., of London.

REINFORCED CONCRETE CHIMNEYS.

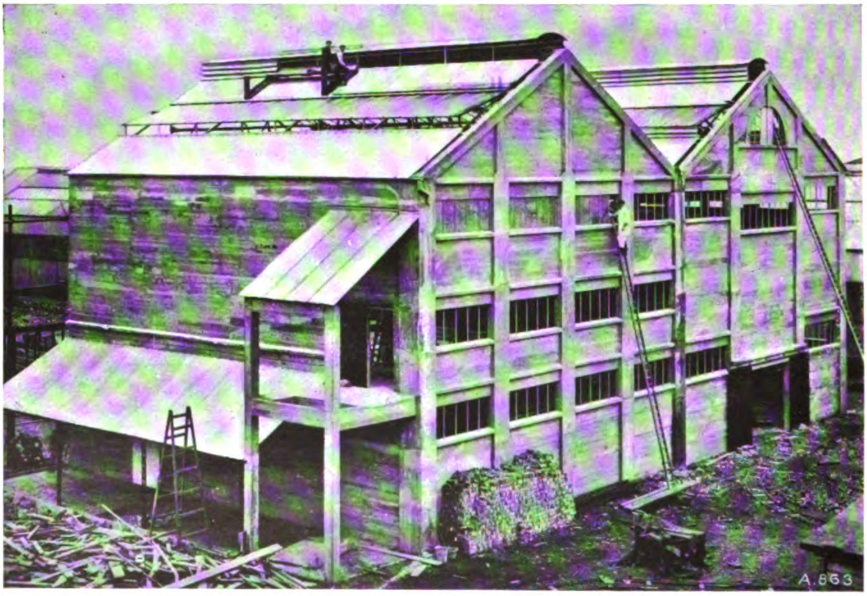
Considerable advance has been made in the use of reinforced concrete for factory chimneys, and quite a number have been completed during the year 1907. Of these we are presenting two instances constructed by the Weber Concrete Construction Co., Ltd., of London, for the Cape Copper Co., Briton Ferry, Glamorgan, and J. & S. M. Greeves, Ltd., Belfast, respectively.

The dimensions of the former are 150 ft. by 13 ft. outer shaft, and 150 ft. by 6 ft. inside shaft, two chimneys being one inside the other, serving two separate furnaces.

The dimensions of the other, at Belfast, are 200 ft. by 8 ft. 6 in.

REINFORCED CONCRETE BUILDINGS AT RAINHAM, ESSEX.

Several warehouses and various other works have been executed in the Coignet system for Messrs. J. C. & J. Field, Ltd. The architects were Messrs. Scott, Hanson & Fraser, of London, and the contractors and licensees Messrs. W. King & Son, of London.



REINFORCED CONCRETE WAREHOUSES AT RAINHAM.

The site is on the riverside, on very marshy ground. The weights of all the buildings are transmitted to the ground by spread foundations in reinforced concrete, and the piling has been reduced to a minimum.

Warehouse No. 4 is a building entirely in reinforced concrete, the approximate dimensions being 120 ft. long by 80 ft. wide. The highest posts supporting roof principals measure 30 ft. The building contains heavy tanks supported by a reinforced concrete structure. Owing to the highly inflammable material contained in various warehouses, the architects thought it advisable to use reinforced concrete throughout. Warehouse No. 7, which is of reinforced concrete, has an area of about 40 ft. by 60 ft. The roof, as in the previous case, is steel work.

The office buildings contain two reinforced concrete floors, measuring about 40 ft. by 40 ft. each, one of which is calculated for a superload of 2½ cwt. per sq. ft.

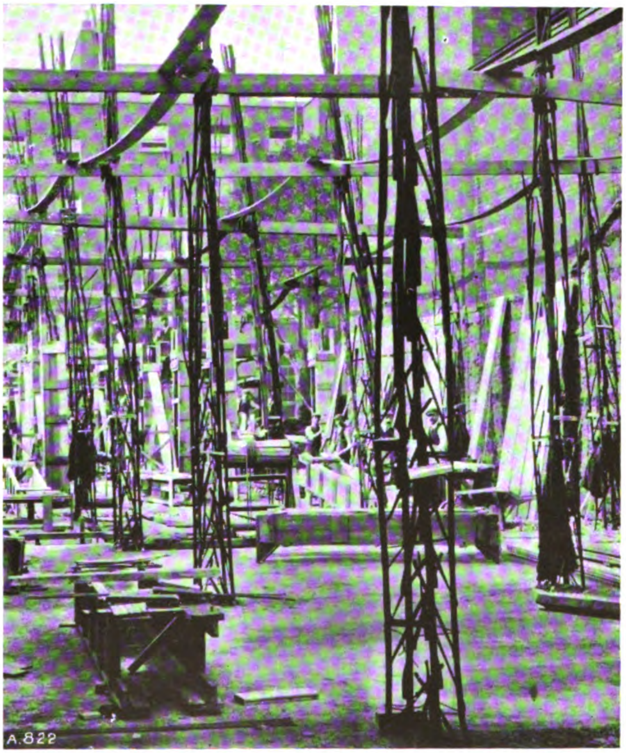
Reinforced Concrete Sheds at Rainham.

No. 8 building contains three reinforced concrete floors at different levels, supporting very heavy tanks and machinery. The engine and boiler house and No. 1 house (measuring about 200 ft. by 40 ft.) have reinforced concrete foundations.

The "Ferrocrete" brand of Portland cement was used.

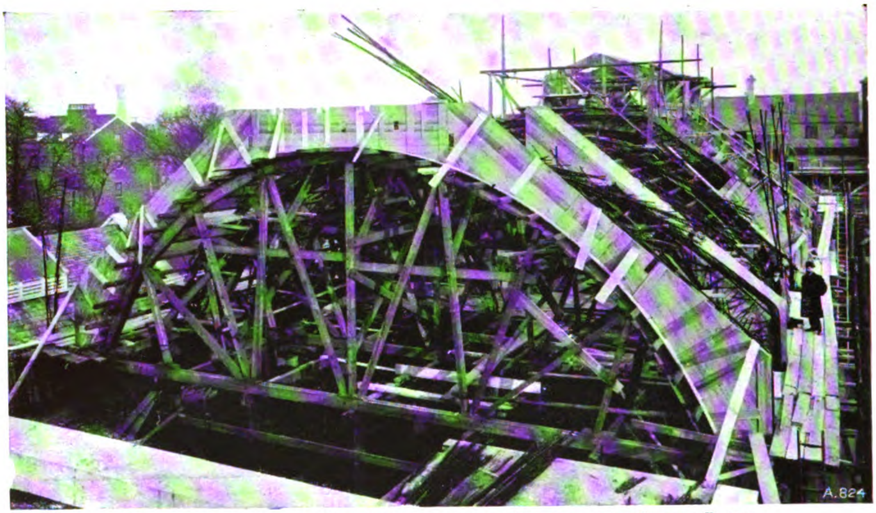
REINFORCED CONCRETE BUILDING FOR THE IRISH LAND COMMISSIONERS, DUBLIN.

The whole of this building is carried on columns and beams in reinforced concrete, including the external walls, which are consequently reduced to a minimum thickness. The floor slabs are carried out on the New Expanded Metal Co.'s system, and the columns (which are shown in course of construction) have been designed with Kahn Bars for reinforcements. The arrangement of the bars can be clearly seen in the illustration.



Reinforced Concrete Columns in Course of Construction at the Irish Land Commissioners' Building, Dublin.

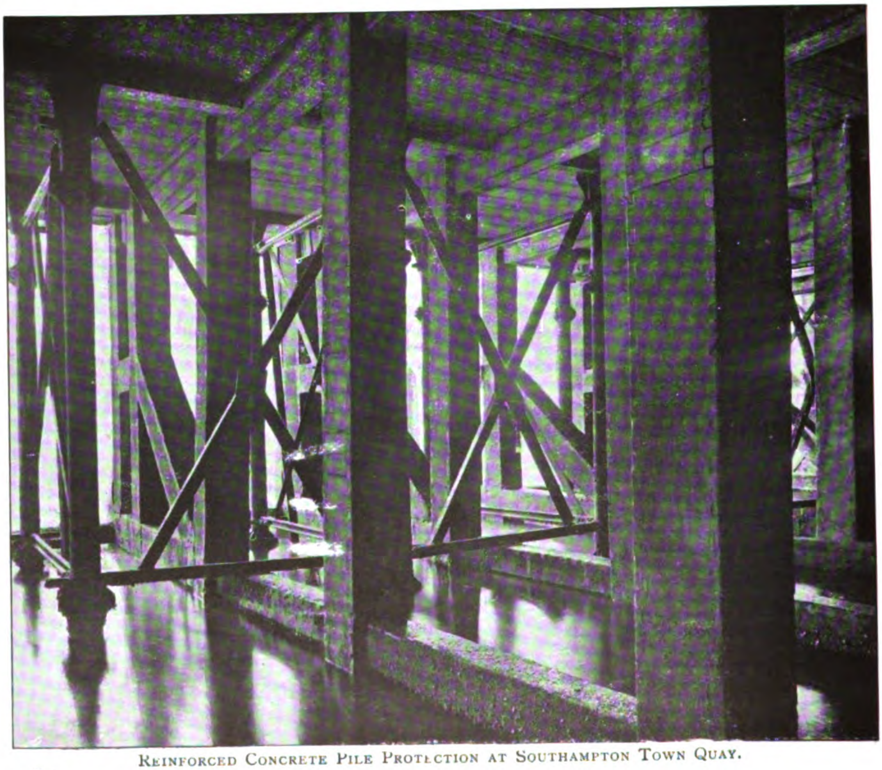
(Showing 'Kahn' bars in position.)



Reinforced Concrete Roof Trusses at the Hammersmith Public Baths.

REINFORCED CONCRETE ROOF TRUSSES AT THE HAMMERSMITH BATHS, LONDON.

This illustration shows the roof principals of the Hammersmith Baths in course of construction. These were carried out without any tie rods or any abutments being provided against the thrust of the arches, which were about 60 ft. span. The reinforce-

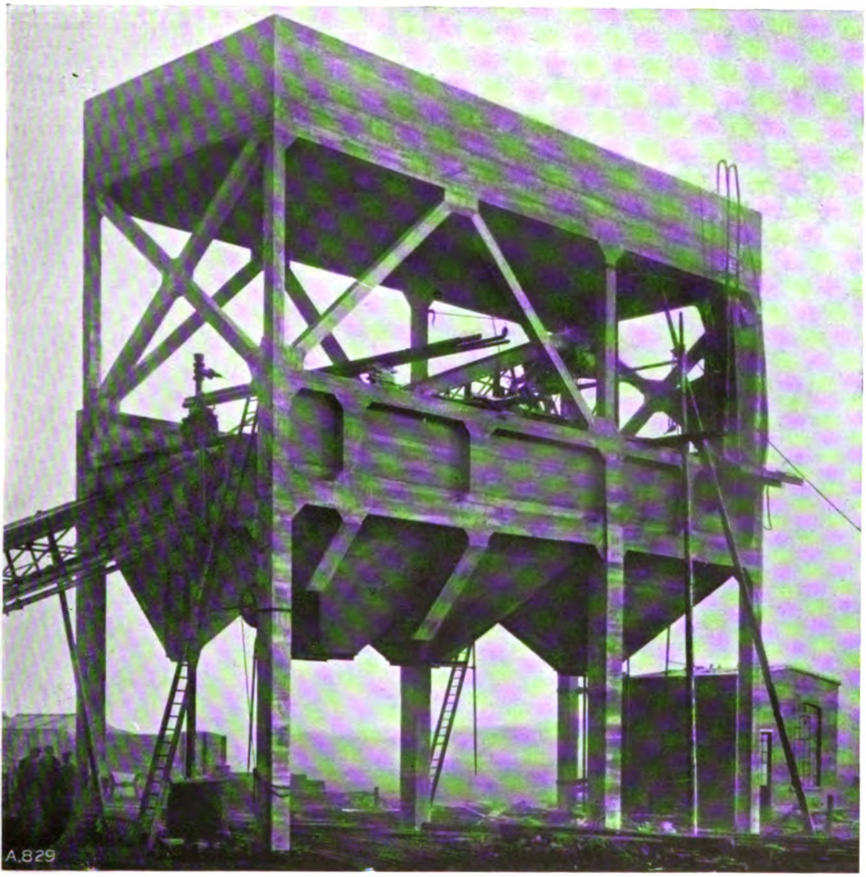


Reinforced Concrete Pile Protection at Southampton Town Quay.

ment throughout comprised Kahn Bars. Some tests with the roof were described on page 503 of our previous issue.

REINFORCED CONCRETE PILE PROTECTION AT THE SOUTHAMPTON TOWN QUAY.

We are indebted to Messrs. D. G. Somerville & Co. for the illustration showing the strengthening of existing piles carried out by them at the Town Quay, Southampton, by means of reinforced concrete slabs. These slabs are placed around angle-iron guides and pressed down to required level, any mud, etc., being pumped or flushed out, and the whole casing then being filled up with concrete.



Reinforced Concrete Coke Hopper and Water Tank at Blackburn

REINFORCED CONCRETE COKE HOPPER AND WATER-TANK AT BLACKBURN GASWORKS.

The reinforcement of the columns is carried out in round bars, with hoop-iron distance pieces. These columns are supported by and jointed to slabs or bases of reinforced concrete of sufficient area to bear the weight superimposed on each column. The structure itself weighs approximately 280 tons, the hoppers when full carry 90 tons of coke, and the water-tank holds 100 tons of water. In addition to this, the coke conveyor, etc., has to be supported, and the shafting for driving the conveyor depends for its rigidity upon the stability of the structure.

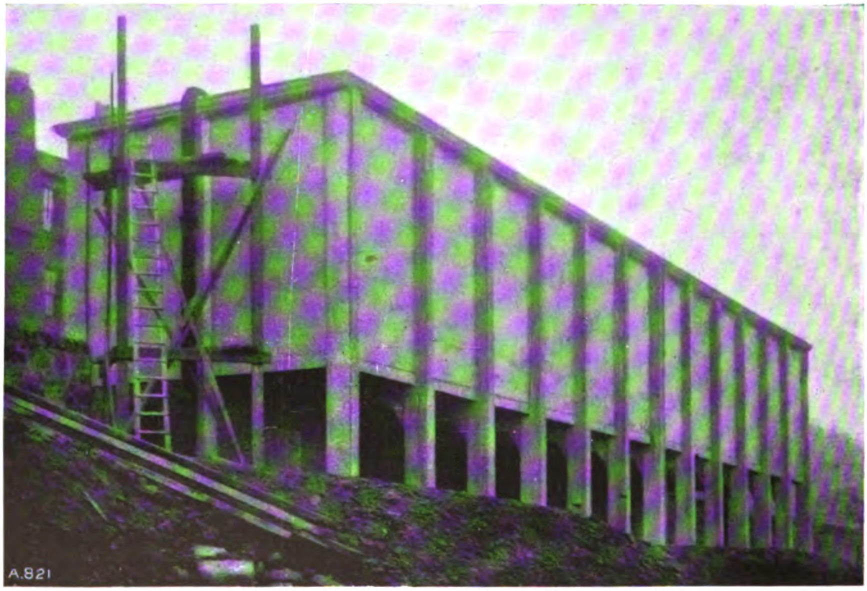
The work was carried out by the New Expanded Metal Co., Ltd., of London.

REINFORCED CONCRETE WATER RESERVOIR AT EDINBURGH, N.B.

There has recently been completed a reinforced concrete elevated water reservoir at Edinburgh to contain 100,000 gallons of water. The reservoir is rectangular in form, instead of the more usual circular type, and the following are the over all dimensions :—

Total length, 92 ft. 6 in.; breadth, 17 ft.; height from ground level, 24 ft. 5 in. The internal dimensions of the tank are 90 ft. in length, by 14 ft. 6 in. in breadth, and the depth of the tank is 13 ft. The maximum possible depth of water is 12 ft., the overflow being arranged for this height.

The entire construction has been carried out in reinforced concrete on the Hennebique system. The elevated bottom of the tank is 5 in. thick, and the side walls 6 in. thick at the bottom, gradually reducing to 5 in. at top. The elevated bottom of the tank is supported by a series of reinforced concrete main beams and secondary main beams, and the total weight of water supported by this bottom, when the reservoir is full, amounts to 450 tons. A rich concrete was used for this work, and the cement used was the "Ferrocrete" brand.



Reinforced Concrete Water Reservoir at Edinburgh, N.B.

From the photograph of the work which we reproduce it will be observed that the reservoir is erected on the edge of a sloping bank of ground, and as this ground was found to be of a somewhat compressible nature, and the load imposed very considerable, the greatest care had to be taken in designing and tieing together the foundations. A grillage of reinforced concrete tie beams was designed for this purpose, and we understand that since construction and the filling of the reservoir with water no movement of any kind has been produced under the severe conditions named, which reflects creditably not only on the value of the monolithic character of ferro-concrete construction, but also on the designer's calculations and carefulness in the matter.

The general designs for the work were made by Mr. James Bell, C.E., and under Mr. Bell's instructions supervision and details were in the hands of Mr. F. A. Macdonald, of Glasgow, to whom we are indebted for the illustration.

CORRESPONDENCE.

Under this heading we invite correspondence.

COLOURING CEMENT PINK.

SIR,—In the March (1907) issue of your journal there appeared a letter signed "F. C. S." giving particulars as to how to obtain various colours in cement work.

Would it be troubling you unduly to ascertain the particulars of the mixture "F. C. S." would suggest for producing a pink colour in cement work, and advise me through your correspondence column?

Also, can he suggest an ingredient which could be mixed with cement to neutralize the staining nature of the oxide of iron when a cement mortar is used in connection with marble work?

Yours, etc.,
W. H. WEBBER.

Bridgwater.

Editorial Reply.

A pink colour in cement can be obtained as follows:—

> 1 part of crimson lake (alumina base) best quality and 15 parts of barium sulphate (common barytes) are ground together and intimately mixed. The product is then thoroughly mixed with 84 parts of Portland cement.

A little cheaper mixture would be obtained by using whiting in place of barytes, but the resulting colour is not so bright.

ACIDS AND CEMENT.

SIR,—We should be obliged if you could give us a reply to this query.

A floor composed of usual proportions of cement and sand seemingly is affected by what is supposed to be acid, such as tartaric and citric and like acids used in preparation of domestic goods, etc.

Is it possible to mix anything with the cement to obviate this, or is it a fact that cement is not affected by such weak acids immediately or in course of time?

Yours, etc.,
ELMORE & SON.

Maidstone.

Editorial Reply.

All cement is liable to be attacked by acids, and even such weak acids as tartaric and citric will cause disintegration of the surface. The best treatment is to brush the cement surface, which should be smooth, with a solution of sodium silicate (fairly concentrated). After treatment the floor may show some powdery efflorescence, but this will wash away, and the silicated surface thus obtained, if allowed time to harden, is very resistant towards acids.

TESTING CEMENT.

SIR,—The present method of fixing the proportions of water and cement by weight leads to serious irregularities in wetness and time of set in pats, and comparative strength in briquettes.

Experiments have satisfied me the nearest approximate which can be made to the same degree of wetness will be secured by adding a given measure of water to a given measure of cement.

The Standards Committee have done good work, and I trust they will investigate this idea, and perhaps get rid of a serious cause of irregularities in testing cement. My tests were limited to pats. I measured the cement in a small meat extract pot, and selected a narrow necked vial which held the required water. Result—much greater uniformity of wetness than when weight was adopted. For briquettes a given measure of cement carefully filled to a certain number of ounces of water will give similar results.

Pats can be made from good Portland cement in such a way that when immediately immersed in water they will be covered with hair cracks on the top side within half a minute.

Yours, etc.,
JOHN WILSON.

Auckland, N.Z.

Editorial Reply.

The method suggested has decided advantages, and we are quite prepared to believe that it gives more uniform results than the usual method of adding a fixed proportion *by weight*.

One improvement we would suggest. It is very difficult to measure cement in such a way as to get the same quantity each time, in fact repeated filling of the same vessel, however carefully done, will give widely varying results. The best way would be to determine the weight of a like "(apparent density)" in a proper apparatus, and then calculate the quantity of water to be added, *weighing* the cement.

For example, if the weight of a like comes out at 1,100 grams, and it is intended to add 10 per cent. of water by volume, each kilogram of cement will require $\frac{1000}{1100} \times 10$—91 cc. of water instead of 100 cc.

CONCRETE IN MINES.

SIR,—The number of fires in our mines is increasing, and in each case the flames make rapid headway owing to the amount of timber we use throughout our underground work.

Could you send me particulars of the application of reinforced concrete for posts, linings, etc., in mines.

The matter of finding a substitute for wood has become all-important in one of our mining districts.

Yours, etc.,
JAMES B. MACDONALD.

Melbourne.

Editorial Reply.

Some notes on the application of concrete and reinforced concrete in mines appeared in our issues of November, 1907, and January, 1908.

An article on the subject appears in the current issue, and another will shortly follow.

INDUSTRIAL NOTES.

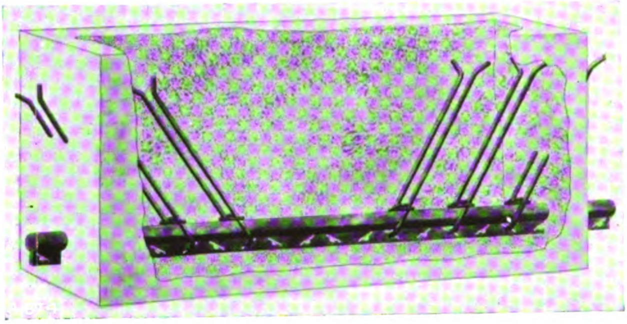
These pages have been reserved for the presentation of articles on proprietary materials or systems of construction put forward by persons interested in their application. They must thus be read as ex parte statements, but we would recommend them to our readers as arguments by persons who are, as a rule, thoroughly conversant with the subject to which they refer.—ED.

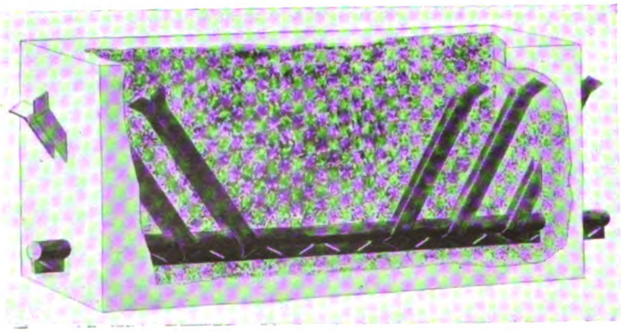
A NEW BAR FOR REINFORCING CONCRETE.

A NEW steel bar for general application in reinforced concrete construction is being placed on the market by Mr. W. H. Brown, M.S.A., of York, and Mr. Percy Tomey, C.E., of Queen Anne's Chambers, Westminster, S.W.

The bar has been called "The Perfector Bar," and the accompanying illustration shows its form and use in beam construction.

The section of the bar consists, as is shown, of a round rod with a flat flange attached thereto. The flange, which is thin in proportion to the diameter to the round rod, is slotted or holed at intervals of a few inches for the insertion of stirrups or shear members. The slots are arranged either horizontally or at an angle of 45°, and when the stirrups are inserted they become firmly fixed either vertically or at an angle of 45°.

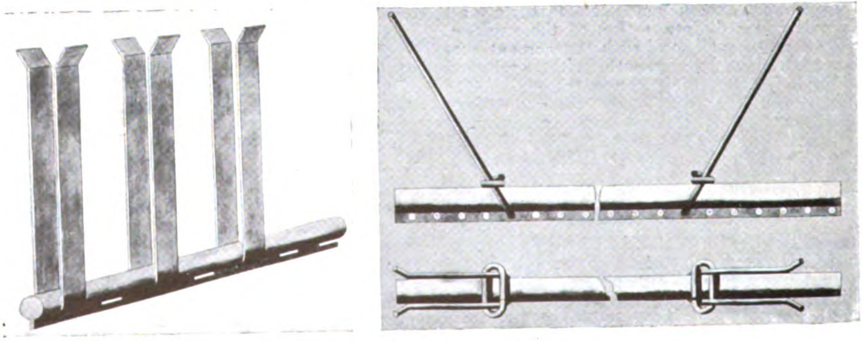




It will be seen that in this form of bar the stirrups or shear members are rigidly attached; their length and spacing are in no way limited, they do not project unduly and cannot be displaced by tamping the concrete; while the bar gives a mechanical bond throughout its length.

The bar permits of plenty of latitude in arranging details, while it affords adequate anchorage and surety against weakening by careless and ignorant workmanship in applying concrete. The steel can, therefore, be estimated to its definite value, and factors of safety become a reality and not a cover for negligence, bad workmanship and uncertainty in theory. The bar can be used with equal advantage in the reinforcement of beams, columns, walls, etc., and its application constitutes a distinct system of construction. Moreover, it possesses the great merit that it can be manufactured at a low cost.

Further particulars can be obtained from Mr. Percy Tomey, to whom all enquiries should be addressed.



THE "PERFECTOR" BAR.

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume III. No. 2. MAY, 1908.

EDITORIAL NOTES.

THE CONCRETE INSTITUTE.

The Concrete Institute, which has come into being with a nucleus of over 100 Founders, should have the support and co-operation of all interested directly and indirectly in the uses of concrete, more particularly in its modern application as reinforced concrete.

The objects of the Institute are given as follows :

(*a*) To advance the knowledge of concrete and reinforced concrete, and direct attention to the uses to which these materials can be best applied.

(*b*) To afford the means of communication between persons engaged in the design, supervision and execution of works in which concrete and reinforced concrete are employed (excluding all questions connected with wages and trade regulation).

(*c*) To arrange periodical meetings for the purpose of discussing practical and scientific subjects bearing upon the application of concrete and reinforced concrete, and to conduct such investigations and to issue such publications as may be deemed desirable.

The Institute will comprise members who have one or other of the following qualifications :

(*a*) Persons professionally or practically engaged in the application of concrete or reinforced concrete, and the production of their constituents.

(*b*) Persons of scientific, technical or literary attainments specially connected with the application of concrete, reinforced concrete, and their constituents.

Besides this there is also a roll of "special subscribers," comprising public authorities, corporations, public companies, and firms desirous of assisting in the work of the Institute or benefiting from its publications.

THE COUNCIL OF THE CONCRETE INSTITUTE.

The Council of the Institute comprises members who are British subjects. There is a President, several Vice-Presidents, a Chairman of Executive, an Honorary Secretary, a Treasurer, and a number of general members of Council.

How representative the first Council is, and what influential support the Concrete Institute already enjoys, may be gathered from the names we are able to give below, and it is indeed remarkable that such influential support should have been obtained within the short period since the idea of the Institute was conceived. It is a matter of congratulation, indeed, that the office of President will from the outset be in such able hands as those of the late First Commissioner of Works, the Earl of Plymouth, C.B., who is perhaps better known as Lord Windsor, under which name he so successfully held office.

As to the Vice-Presidents, concrete could not be better represented, as far as the architectural side is concerned, than by Sir Henry Tanner, I.S O., F.R.I.B.A., who has been a pioneer in the application of reinforced concrete to Government work, and who so ably presided as Chairman of the Reinforced Concrete Committee. The older school of Civil Engineering is represented by Sir William Preece, K.C.B., F.R S., a Past President of the Institution of

Civil Engineers, who has held public appointments of importance and is Chairman of the Special Commission on Concrete Aggregates. Sir William Mather, LL.D., M.Inst.C.E., as Vice-President, ably represents the great industrial interests of the country, for not only is the firm over which he presides a notable one, but he has long been an active worker on many technical commissions.

The office of Chairman of the Executive is in the hands of Mr. Edwin O. Sachs, F.R.S.Ed., an architect who has devoted considerable attention to the technical and research side of his profession, and is Chairman of the British Fire Prevention Committee.

The first Honorary Secretary is Mr. A. E. Collins, M.Inst.C.E., the City Engineer of Norwich, whose practical experience of reinforced concrete is considerable, and who has had seats both on the Reinforced Concrete Committee and on the Special Commission on Concrete Aggregates. He is also an immediate Past President of the Association of Municipal Engineers. These honorary offices all keep him in the closest possible touch with the various professional and industrial aspects of concrete and reinforced concrete.

The Honorary Treasurer is Mr. E. P. Wells, one of the few British designers in reinforced concrete, and whose research work in concrete is well known.

Regarding the other members of Council, as far as we are informed up to the present, they comprise (alphabetically arranged) Messrs. H. H. D. Anderson; Bertram Blount, F.I.C.; C. H. Colson, M.Inst.C.E. (Supt. Civil Eng., Admiralty); William Dunn, F.R.I.B.A.; Ben Hannen, B.A.; W. T. Hatch, M.Inst.C.E., M.I.Mech.E., (Eng.-in-Chief, Metropolitan Asylums Board); W. H. Hunter, M.Inst.C.E., M.Am.Soc.C.E. (Chief Eng., Manchester Ship Canal); W. H. Johnson, B.Sc. (Chairman, Johnson, Clapham and Morris); Chas. F. Marsh, M.Inst.C.E., M.Am.Soc.C.E., M.I.Mech.E. (of the Metropolitan Water Board); Frank May, J.P. (Chairman, Trussed Concrete Steel Co.); J. Munro (Director, Stuart's Granolithic Co.); F. Purton (Manager, New Expanded Metal Co.); A. Ross, M.Inst.C.E. (Chief Eng., Great Northern Rly.); L. Seraillier (Manager, Patent Indented Steel Bar Co.); J. S. E. de Vesian, M.Inst.C.E. (Mouchel and Partners); Lieut.-Col. J. Winn, R.E., A.Inst.C.E. (late Instructor, School of Military Engineering); and G. C. Workman (Coignet System). To deal in detail with the experience of these members of the Council is impossible, but the offices they hold and the work they have done should give the greatest confidence to the members of the Institute.

The professional element is necessarily and rightly in the majority in such a Council, for it is the general interests of the community that have to be advanced in institutions of this type, and not the interest of any one trade or industry. The industry as a whole naturally largely benefits by the existence of such an institution, for its deliberations lead to a better understanding between all the interests concerned. The amount of work that has to be executed is increased owing to the greater confidence accorded, and, above all, the existence of such an institution gives the work a recognised place. But the primary aim must be to give the British public serviceable, reliable, and economical structures, and to give the public authorities and professions concerned the best possible unbiassed knowledge of the subject under review. In the Iron and Steel Institute these principles have been grasped and maintained for many years, and we trust they will be fully realised by the Concrete Institute, which we wish every success.

The first offices* are at No. 1 Waterloo Place, Pall Mall, S.W., where all communications should be addressed to the Honorary Secretary.

REPORT ON THE QUEBEC STEEL BRIDGE DISASTER.

We have previously commented on the fact that the Quebec disaster, involving the loss of some 80 lives and £500,000 of money, called for but little attention in this country, whilst any accident involving perhaps the loss of only £500 with a reinforced concrete structure is generally made the subject of extensive denunciation and adverse criticism.

The report of the Royal Commission appointed by the Canadian Government to investigate this terrible disaster has been issued. It is one of the most lucid and painstaking documents ever prepared in respect to an engineering disaster. Not only as a record of facts, but for its deductions, it stands in a foremost position amongst writings of its type.

Yet again, this report has scarcely called for the slightest attention among our daily contemporaries, and even our technical journals, with one or two notable exceptions, apparently consider this bridge disaster ancient history, and do not devote any space to the report.

The subject-matter is to a great extent outside our purview, but some of the deductions are equally applicable to reinforced concrete as to steel.

SOME LESSONS FROM THE DISASTER.

The principal lesson to our mind is that every structure of importance requires either a highly-trained, responsible engineer or architect permanently or at least regularly on the spot. To leave important structures to representatives lacking high technical training and experience is wrong. No matter how practical and experienced the clerk of works may be, his horizon is, with but few exceptions, necessarily not a wide one. Had there been a man on the spot of the technical training we claim is necessary he would have immediately realised that the faults observed in the Quebec Bridge were of extreme importance; he would have stopped the progress of the works, and at least no lives need have been lost, for there was ample time for the necessary precautionary measures.

A second lesson to our mind is that on no structure should engineers or contractors be tempted to cut their work too finely, whether, as the case may be, for reasons of economy in the interests of the employer; with the object of obtaining an increased profit for the contractor, or, as is too often to be seen, for reasons of mere technical vanity and bravado. There is not the least doubt that the contractor's design in this case was "cut" too finely, and likewise the consulting engineer had, if anything, a tendency to cut the quantity of the steel used, either for reasons of professional vanity, or in the interests of the employer.

Loads and dead weights were taken too finely, stresses and strains that should have been provided for were underestimated, and the result has been that both designer for contractor, and consulting engineer are held responsible for the disaster, with its fearful loss of life and property.

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* The annual subscription for members upon election is a reasonable one—namely, one guinea—and there is no entrance fee at the moment. The "Special Subscribers"—*i.e.*, those firms joining in their corporate capacity—have to pay a subscription of five guineas, with an entrance fee of five guineas. These firms do not become members as firms, but have the right to nominate a representative for election. The institute is being incorporated as a corporate body.

In what degree the responsibility is to be divided between the designing engineer and the consulting engineer, the Commissioners have not attempted to define, for there were certainly faults on both sides, and as such cases of divided responsibility easily occur with reinforced concrete structures to-day, we specially point to this aspect of the finding. For reinforced concrete structures the contractor or specialist is all too often called upon to prepare the designs on the scantiest of information, and the consulting engineer is commissioned to check the design with little or no knowledge of the special characteristics of reinforced concrete. Thus there is the danger of an incorrect design based on insufficient data and the risk of a checking of but little value.

The fact is distinctly stated that the collapse could not have been due to any abnormal weather conditions or accident, *i.e.*, "was solely due to errors in judgment and errors in specification." The material appears to have been excellent, and every care exercised in the execution of the work. There was, however, a lack of knowledge of the principles underlying the design, and a tendency to bravadoism. These are just the conditions to be met with in reinforced concrete.

It is only to be hoped that the primary lessons will be borne in mind by all concerned in reinforced concrete.

THE DRURY LANE THEATRE FIRE AND REINFORCED CONCRETE.

The fire at Drury Lane Theatre appears to have been an object lesson as to the utility of precautionary measures in fire prevention in no small degree. As far as we can observe, there were, however, more object lessons in the matter of equipment than in actual construction.

While certain ventilation facilities, the fire resisting curtain, certain screens, doors, etc., did their duty, the fact remains that the stage roof was still supported by trusses of timber construction as of old.

Theatres are structures peculiarly prone to be the subject of fires, and we would thus point out that there are no structures where reinforced concrete is more suitable than in the construction of the stage of a theatre.

The large wall surfaces, the roof trusses, etc., all lend themselves essentially to reinforced concrete construction. It might, of course, be suggested that steel should be the substitute for timber in the trusses, but in such a case the steel would have to be protected by concrete, and therefore reinforced concrete trusses would certainly be considerably more economical and more effective than steel framing cased in.

Altogether we should like to see reinforced concrete utilised more in the sense of a fire resisting material and intended to overcome the complications of steel framing protected by concrete. If reinforced concrete is really well designed and carefully executed from a fire point of view, with a suitable specification of the aggregate, the aggregate size, the thickness of the covering to the steel, and the nature of the finely-ground Portland Cement, no more practical form of fire resisting construction could be desired than that of reinforced concrete. But great care is necessary both in the correct specification and the execution of the work.

THE HISTORICAL EVOLUTION OF REINFORCED CONCRETE IN HUNGARY

By **JOSEF SCHUSTLER**, Budapest.

(*Translated from the German.*)

We have previously dealt with the Historical Evolution of Reinforced Concrete in various countries, in France, Germany, Austria, Italy, Switzerland and Holland, and we are continuing the series by a similar article in respect to Hungary.

It is our intention to present similar articles dealing with other countries, so that the series when complete may take the form of what will be practically a Universal History of the Development of Reinforced Concrete.—ED.

It is generally conceded that Hungary may rightly be considered one of the cradles of reinforced concrete, as at an early period distinct systems were developed there, independently of the west of the Continent, and in course of time these systems have attained a wide popularity. Other systems of reinforced concrete construction introduced from abroad have likewise been freely applied by Hungarian engineers, and, in fact, speaking generally, works in reinforced concrete have been carried out in Hungary which rank among the masterpieces of this form of construction.

The first application of reinforced concrete in Hungary was in the erection of stables at the Artillery Barracks, in Kassa, in 1886, by Robert Wünsch, of Budapest. Steel and concrete were used on that occasion on a plan known in Austria seven years later as the Melan system. The defect of this construction—namely, the unavoidable thrust of the vault—led Wünsch to modify his system in such a way as to avoid this defect by anchoring the separate metallic ribs. The Wünsch system arrived at in this way, has found wide application in Hungary, and has also been repeatedly adopted in Austria. A large floor on this system was constructed in 1892 at Dreyer's Brewery, in Budapest. The floor is calculated for a working load of 1,200 kg. per sq. m. and consists of flat barrel-vaults carried by flat reinforced concrete arches.

Fig. 2 represents the bridge over the River Nyitra, also constructed in 1892 on the Wünsch system. It consists of five reinforced concrete arches, each of 17 m. span and 1-15 m. rise. The greatest span of any bridge on this system is the Kaiser Bridge, at Sarajevo, in Bosnia, which was erected in 1896 and has a span of 25·36 m. It is interesting to note that, even in the 'nineties, bridges were constructed on this system with arched ribs and decking—that is, similar to the most modern type of long-span reinforced concrete bridges.

The Monier system was introduced into Hungary in 1887 by the German engineer G. A. Wayss, and since then very many floors, some large domes, and a series of barrel-arched bridges have been carried out on the Monier system. It is a peculiarity of the development of reinforced concrete in Hungary that, in contrast to the conditions abroad, it has been employed, first by engineers in bridges, and only later for floors in buildings.

The Hungarian engineer Matrai's system grew out of the Monier system in 1893, and has been widely adopted, not only in Hungary, but over the whole Continent from Paris to St. Petersburg, and even beyond the ocean, and is now often met with as a light and cheap construction for the floors of dwelling houses.

The first plate-beams, in the modern sense of the word, were also constructed by Wünsch in 1899, in Hungary, and were first applied on an extended scale by Eugen T. Kis in the Imperial Army Clothing Department, at Budapest. The beams were reinforced with I-iron, anchored to the plate with hoop-iron stirrups; the plate was reinforced with I-iron. A similar system of plate-beams was employed by Johann Feketschazy in 1899, and has likewise been used for the floors of many dwelling houses.

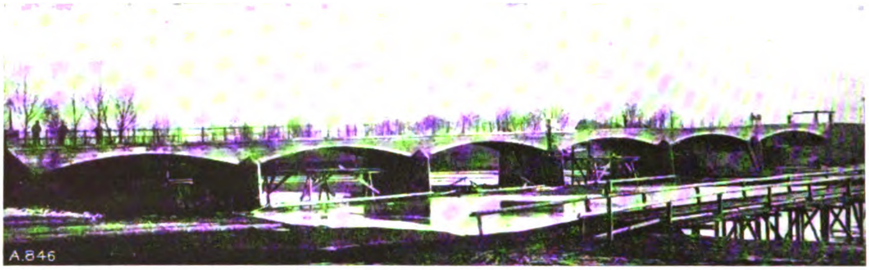


FIG. 2. REINFORCED CONCRETE BRIDGE ON THE WÜNSCH SYSTEM OVER THE RIVER NYITRA AT ERSEKUJVAR.

The first reinforced concrete columns were also erected by E. T. Kis, in 1900, for the warehouse floor of the Military Commissariat Department, at Székesfehérvár; these were reinforced with four angle-irons, connected by rings instead of stirrups. This mode of construction has recently been recommended by Dr. Fritz von Emperger. When the warehouse was enlarged, a year later, the Hennebique system was applied by the engineer, Dr. Constant von Zielinszky.

Simultaneously with the invention of the Siegwart beam in Switzerland, in 1902, the first tests were made with the Hungarian engineer Dr. Johann Kossalka's I-shaped reinforced concrete beam, which was followed in 1903 by the Visintini beam, successfully introduced into Hungary by the writer. Many stable, warehouse, and dwelling-house floors, as well as heavily laden bridges of small span, have been executed in Hungary with Visintini beams. Such a bridge, of 4·7 m. in span, to carry vehicles of 20 tons, is seen in *Fig.* 3.

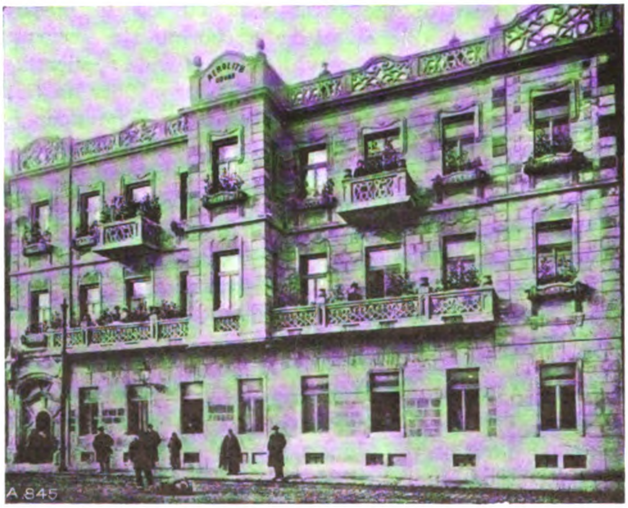


FIG. 4. DWELLING HOUSE CONSTRUCTED WITH "AEROLITH" HOLLOW CONCRETE BLOCKS, BUDAPEST.

An interesting modern mode of using reinforced concrete is to be found in connection with the hollow block, which was employed in 1903 by Eugen T. Kis, under the name of "Aerolith." Some hundred buildings of different kinds have been erected on this system. *Fig.* 4 shows such a four-storied dwelling-house, erected in Budapest with reinforced concrete framing and "Aerolith" hollow blocks.

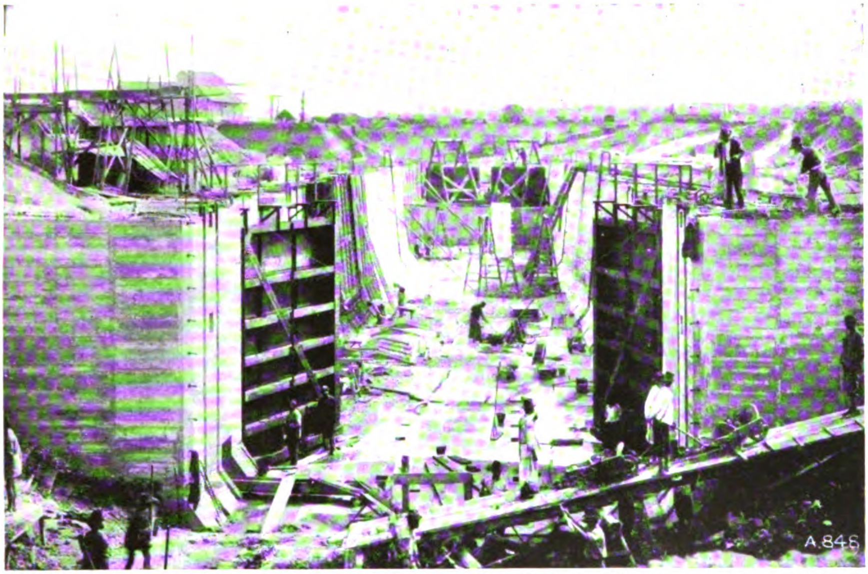


FIG. 6. REINFORCED CONCRETE DRY DOCK AT BÖKÉNY.

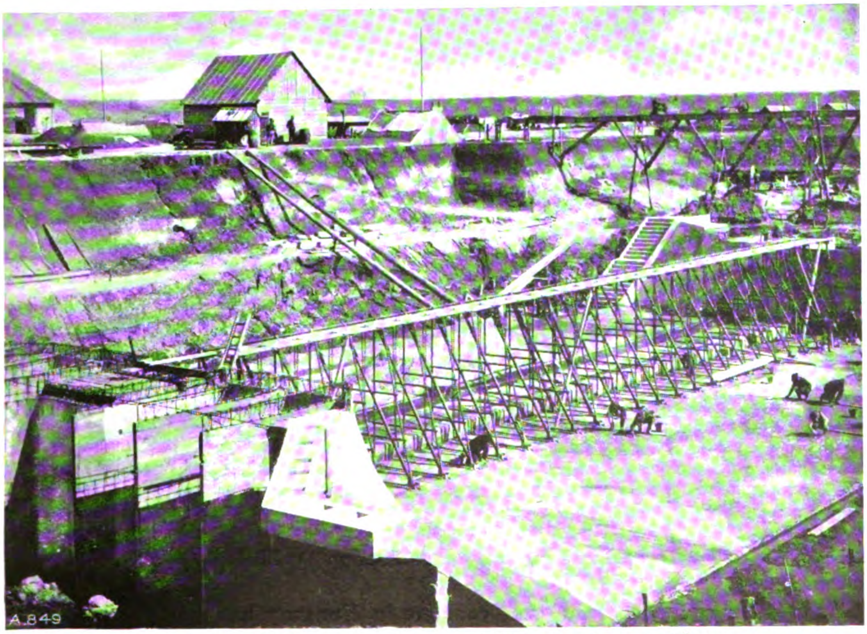


FIG. 7. POIRÉE WEIR, WITH REINFORCED CONCRETE SOLE, AT BÖKÉNY.

Much progress has also been made in the theory and the literature of reinforced concrete in Hungary, and the names should be mentioned of Prof. Desider von Nagy, of the Royal Polytechnic, who in 1901 conducted theoretical investigations into the strength of beams subjected to bending, and of Dr. Johann Kossalka, lecturer in the same Polytechnic, who in 1905 exhaustively and instructively investigated the theory of continuous beams with multiple supports. Last year Dr. Béla Bresztovsky published the results of his extensive compression tests to determine the mechanical properties of concrete. Finally, we have been, since 1906, in possession of a very thorough descriptive work on reinforced concrete construction by Messrs. Josef Beke and Karl Richter.

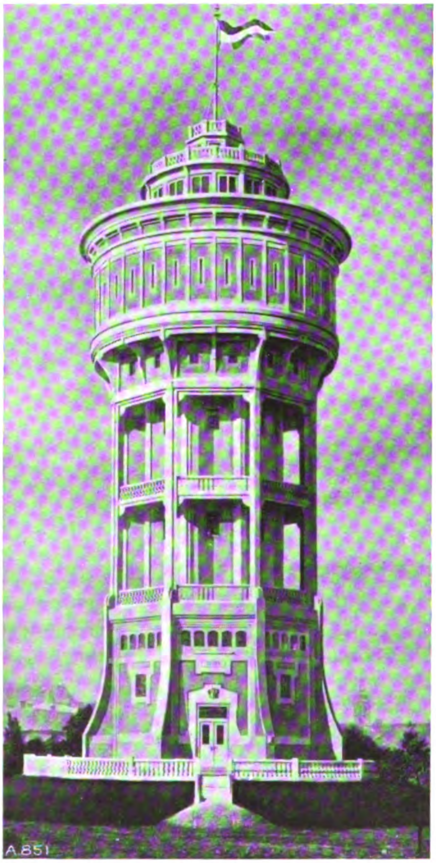


FIG. 8. REINFORCED CONCRETE WATER TOWER ON THE HENNEBIQUE SYSTEM AT SZEGED.

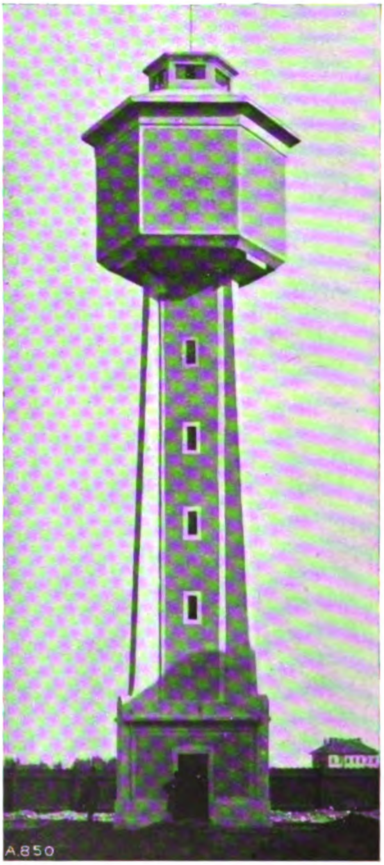


FIG. 9. REINFORCED CONCRETE WATER TOWER ON THE BALOGH SYSTEM FOR THE BUDAPEST POST OFFICE.

As in other countries, reinforced concrete in Hungary has made enormous strides in the last five years, both in foundations and in superstructures, and in the following figures I shall only illustrate and shortly describe some of the most notable erections.

I have already referred to the most important of the older bridges, but the largest recent example of this kind must not go without mention—namely, the arched bridge now in course of construction at Garam Kövesd, over the River Garam. This bridge, designed by Prof. Aladár von Kovács-Sebestyén, spans the river with three arches, each of 40 m. span (see *Fig.* 5.) Each span has only two arched ribs, on which the road, constructed of T-beams, rests by means of short pillars. The contractors are the Hungarian Concrete and Reinforced Concrete Co., formerly G. A. Wayss & Co.

I must not omit to mention that the first reinforced concrete railway bridge in Hungary was opened to traffic in November, 1907. The bridge is near the Sztrecsény Station on the Kassa-Cderberger Railway, and carries two lines. It has a span of 4·3 m., and is calculated for a load of 19 tons on each axle. It is remarkable that only one half of the bridge was constructed on the piers, the other half being constructed on a framing placed alongside and moved into place after setting.

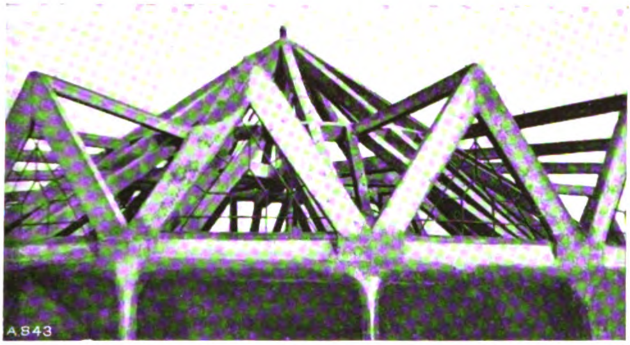


Fig. 10. Reinforced Concrete Roof Framing of the Greek Catholic Church at Szepesjakabfalva.

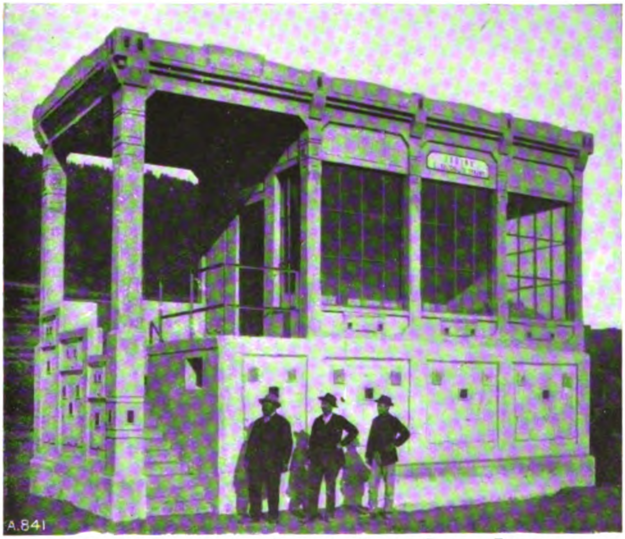


Fig. 11. Reinforced Concrete Signal Box at Zsolna.

Although Dr. Fritz von Emperger, in his latest handbook (1907), writing of docks, was unable to bring forward any example in reinforced concrete, but could only express his opinion that "reinforced concrete is specially suitable for these purposes," yet in Hungary the first great reinforced concrete dock was completed two years ago. This is the dry dock at Bökény (seen in *Fig.* 6), at the junction of the River Körös with the Tisza, which was constructed in 1905 by the firm of Heinrich Freund & Sons, of Budapest, from the designs of Prof. Constant Zielinszky. The dock is 93 m. long by 10 m. wide, and was constructed entirely of reinforced concrete, the surrounding soil being extremely wet. The Poirée Weir (illustrated in *Fig.* 7) is in connection with the dock, and is 35 m. broad and 21·5 m. long. The sole and sill are anchored to the soil by means of reinforced concrete piles in order to resist thrust. Both of these structures have remained in perfect condition during the two years.

The water tower at Szeged (*Fig.* 8) was also designed by Dr. Zielinszky, and was the first erection of the kind in Hungary. It was constructed in 1904, entirely of reinforced concrete, including even the flagstaff, 10 m. high. The capacity of the tank is 1,000 cub.m., and the height of the floor above ground is about 40 m. The mode of execution should be mentioned, as the tower was erected by means of a self-supporting movable scaffold.

A very original design is that of the dovecot-like water towers for the Royal Post Office at Budapest, and the Hospital at Mármarossziget, designed by Koloman Balogh and erected by the writer, the first of which is represented in *Fig.* 9. The capacity of this tower is 50 cub. m. and the height of the floor above ground 20 m.; the other tower is of 100 cub. m. capacity and height 17 m. The peculiarity of the construction lies in the fact that the hexagonal reservoir is carried by only three radial columns, the inner angles of which, connected by thin reinforced concrete walls, enclose the staircase. This gives the maximum carrying power with the minimum expenditure of material.

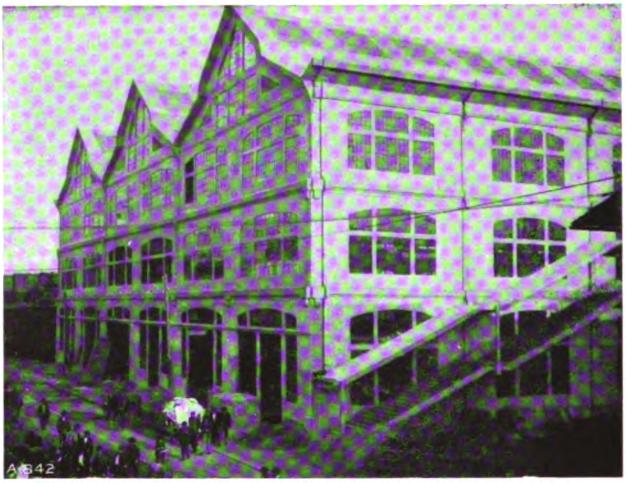


Fig. 12. Reinforced Concrete Crane Mounting Shop, Ganz Works, Budapest.

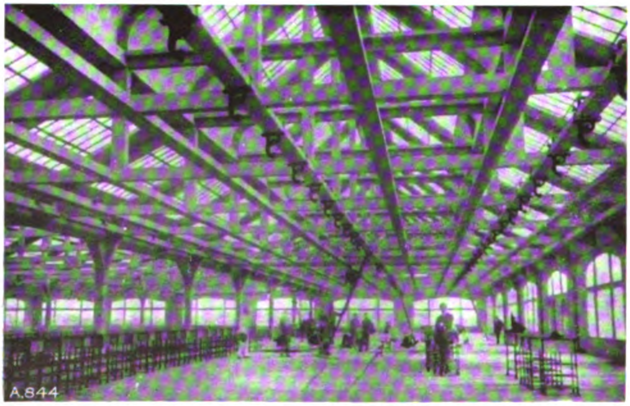


Fig. 13. Interior of Crane Mounting Shop, in the Ganz Works, Budapest, Showing Reinforced Concrete Beams on the Hennebique System.

Passing to buildings proper, the roof-framing and dome of the Greek Catholic Church at Szepesjakabfalva (*Fig.* 10) should be noticed. This is an interesting example on account of the peculiarity of its construction. The whole structure rests on the four main columns of the dome, through a rectangular arrangement of beams, the rectangle then passes into an octagonal figure, and this again into a sixteen-sided figure. This last figure takes the entire lateral thrust of the rafters without any radial connections, the use of the latter being impossible owing to the presence of the inner dome.

The reinforced concrete signal boxes at the Zsolna Station, on the Kassa-Cderberger Railway, one of which appears in *Fig.* 11, deserve attention on account of the somewhat unusual use to which the material has been put. The appearance of the boxes, too, is quite different from that of the usual signal cabin, and offers an agreeable variation from the general monotony of such buildings.

A building of technical interest is the crane-mounting shop of the Ganz Machine Works, in Budapest, constructed entirely in reinforced concrete and illustrated in *Figs.* 12 and 13. This was erected in 1905 by the Messrs. Heinrich Freund & Sons, from the plans of Dr. Constant Zielinszky. The three-aisled building is 80 m. long, 52·5 m. wide and 24 m. high from floor to ridge. The span of each aisle is 17·4 m., and two are fitted with travelling cranes, whilst the third is divided into storeys and serves as workshops. The ways for the travelling cranes are reinforced concrete beams, supported by columns at intervals of 8·8 m.; the lower rails, at a height of 7 m.,

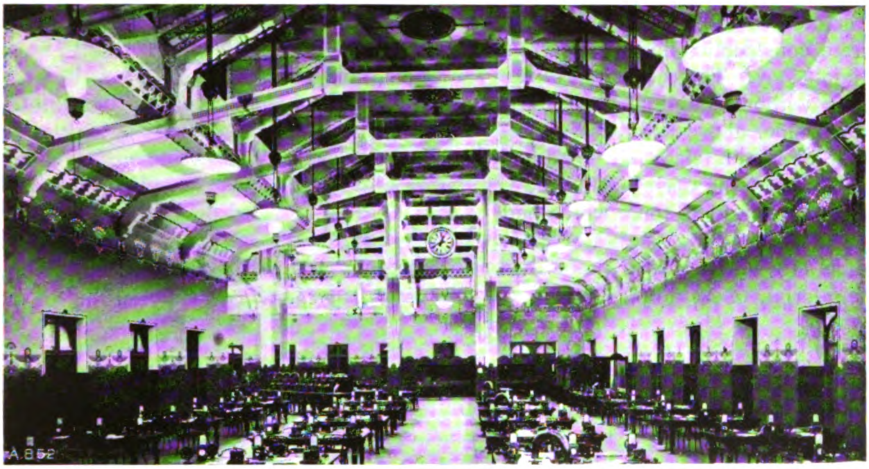


Fig. 14. Central Telegraph Hall, General Post Office, Budapest
Showing Reinforced Concrete Roof Trusses on the Hennebique System.

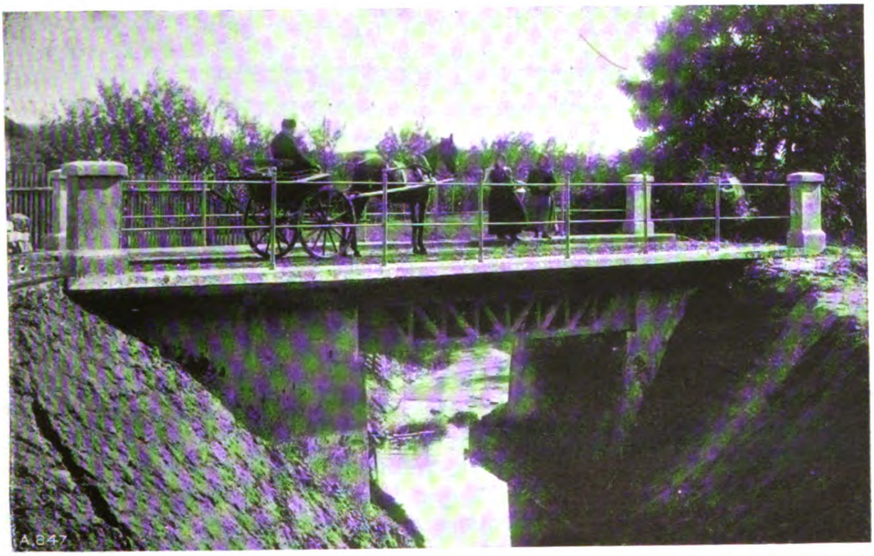


Fig. 3. Reinforced Concrete Bridge on the Visintini System, with a 4·7 m. Span, at Nyvigyhaza.

carry two cranes, each of 10 tons capacity, whilst the upper, at a height of 12 m., take a 30-ton crane. The ways were calculated as continuous beams with multiple supports. The intermediate workshop floor, seen in *Fig.* 13, is calculated for a working load of 1,000 kg. per sq. m.

Fig. 14 represents the roof of the new Central Telegraph Hall of the General Post Office, in Budapest. This L-shaped room, 110 m. long, 16·5 m. wide, by 10 m. high, was erected in 1906 in the building of the old General Post Office. The reinforced concrete construction is due to Dr. Zielinsky, whilst the architectural design is due to Rudolf Ray. The roof-trusses are 3·7 m. apart, and were calculated as rigid frames (lattices without diagonal struts) with the aid of the theory of elastic deformation. On each side, above the trusses, passages are constructed for the whole length, and serve to carry the telegraph wires and also the ventilating and heating arrangements. Above the roof the uprights for the ventilators are placed, and transmit to each truss a lateral tension of 18 tons, which had, of course, to be provided for in the calculations. This hall is one of the sights of Budapest, not only for the engineer, but also for the architect, to whom it is a proof that reinforced concrete, although still somewhat a new material, offers ample scope for architectural treatment.

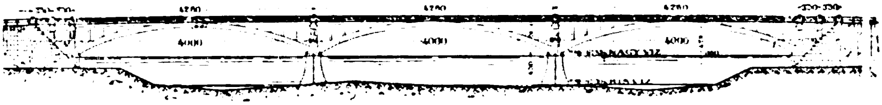
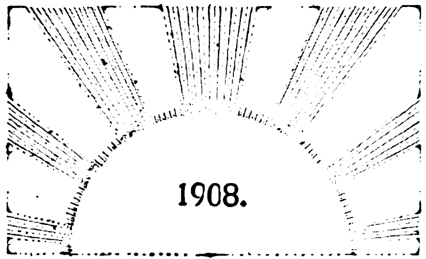


Fig 5 Reinforced Concrete Arched Bridge at Garam Kövesd.



CHARACTERISTICS OF THE CHIEF SYSTEMS OF REINFORCED CONCRETE APPLIED TO CIVIL ENGINEERING WORKS IN GREAT BRITAIN.

A SUMMARY WITH TABLES.

This article is in continuation of one published in our January issue on the Characteristics of Reinforced Concrete used for Building Construction in Great Britain, this section being devoted entirely to the Civil Engineering side.

The previous article dealt with Reinforced Concrete Beams, Floors, Columns, Walls and Partitions, Chimneys, Piles, Pipes, while the one presented below deals with Bridges, Quays, Jetties, Piers and Reservoirs.

The two articles should be read together.—ED.

PART II.

In accordance with the many requests received, the article which was descriptive of the various systems of applying reinforced concrete to building construction in this country, and which was published in our January issue, is now being supplemented with some particulars of various systems of applying reinforced concrete in Civil Engineering.

The principle adopted in the previous article has been retained—namely, that of giving particulars of so-called systems in alphabetical order, and then tabulating the principal features in the same order. This article deals with bridges, quays, jetties, piers, and reservoirs, and the quays, jetties, and piers have been grouped under one heading.

Our chief difficulty, however, has been as before, to come to some decision as to what should be included under the heading of "systems" of construction, and in some instances we have had to decide not only whether the form of construction might be termed a *bonâ fide* system, but also whether we are describing what was actually reinforced concrete.

In arriving at the results presented, we have been guided simply by what we would term the existence of a specific process or system of design which is kept to under varying conditions, and this has naturally excluded the work of some well-known designers, such as Mr. Wells, who, we think, are rightly more inclined to vary their method of design according to the circumstances underlying their work than the majority of owners of what we might term proprietary or patented systems.

Regarding the question as to whether we were dealing with reinforced concrete at all or not, we have not been able to keep to any hard and fast rule, but generally it might be said that we have limited the description of reinforced concrete to concrete reinforced by small bars or sections rather than where the reinforcement takes the form of joists, when to our mind the work becomes a combination of steel framing and concrete, and cannot rank as reinforced concrete proper.

We trust that these details may, as was apparently the case with the article dealing with Building Construction, have the approval of the majority of our readers, for we are aware that opinions are divergent as to what should be included and what be omitted.

In any case, we still assume that the summary will be useful for the purpose of rapidly arriving at a conclusion as to what is immediately available in reinforced concrete for Civil Engineering work, and, read together with the previous article, the details we now present should be valuable for reference purposes.

In presenting the article we must repeat what we have stated before, that the progress being made with reinforced concrete is indeed rapid, and that the number of instances in which the systems to which we refer are being applied are increasing from day to day. With due care in design and workmanship, this popularity should not only continue as at present, but deservedly increase, for where the design is sound, the materials good, and the workmanship of high quality, reinforced concrete, both for practical and economical reasons, should command the widest possible application in the Civil Engineering work in this country.

BRIDGES.

(1) Coignet System.—*Type A.*—Girder bridge having longitudinal and transverse beams and deck slab of monolithic construction throughout, designed and reinforced substantially as described under the heads of BEAMS and FLOORS.*

Type A1.—Trestle girder bridge, where the girder spans are carried on a series of frames with columns and bracing reinforced in the manner characterising this system and described under the heads of BEAMS and COLUMNS.†

Type B.—Arch bridge with two or more ribs, or one rib extending from side to side of the span, supporting solid or pierced spandrils upon which is carried the decking. The arch ribs are reinforced by longitudinal bars near the intrados and extrados, by transverse bars and also by diagonal or radial bars for taking up shear. The ribs are usually treated as arches fixed at the abutments and the work is monolithic throughout.

(2) Considère System.—*Type A.*—Girder bridge having main and secondary beams and a continuous decking, the whole reinforced in the manner described under the head of BEAMS.‡

Type B.—Bowstring girder bridge, wherein the lower boom is reinforced in the ordinary manner by longitudinal bars and bars bent up near the supports, and the upper boom is reinforced by a spiral coil and longitudinal bars similar to that employed in this system for COLUMNS.§

The bracing between the booms consists of ties and struts, the former reinforced by straight bars and the latter by straight bars and spiral coils.

The advantages claimed for this method of construction are the high resistance of the compression members and the economy thereby secured.

Type C.—Arch bridge, with ribs reinforced by longitudinal bars and spiral coils; spandrils of the open type with bracing; decking carried by longitudinal and transverse beams. All compression members are reinforced by spiral coils and longitudinal bars, and all tension members by straight bars with suitable provision for shear.

The advantages claimed for this form of design are exceptional strength and economy.

(3) Expanded Metal System.—*Type A.*—Girder bridge with reinforced concrete decking, in which expanded metal sheets are applied for resisting tensile stresses near the under surface and near the upper surface above the girders, the latter members being of concrete reinforced against tension and compression by light, round steel bars, and against shear by strips of expanded metal applied vertically as stirrups and wrapped around the longitudinal reinforcement.

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* Vol. II., No. 6, pp. 429 and 434; † Vol. II., No. 6, pp. 429 and 437; ‡ Vol. II., No. 6, p. 430; § Vol. II., No. 6, p. 438.

Type B.—Girder bridge with two or more main girders consisting of rolled steel joists or built up of any suitable rolled steel sections, and the decking of concrete reinforced by expanded metal.

The steel girders are embedded in concrete, which serves as an efficient protection against corrosion and obviates the necessity for periodical painting.

The concrete of the decking is monolithic with that encasing the girders, and the expanded metal reinforcement is bent around those members, with the major axis of the meshes perpendicular to the axis of the bridge, the sheets of reinforcement being curved in accordance with the form of the diagram of bending moments for uniformly distributed loading, thus rendering unnecessary any auxiliary reinforcement for withstanding shear.

(4) Hennebique System. — *Type A.*—Parallel girder bridge, consisting of two or more longitudinal girders, and transverse beams if necessary, connected by a deck slab. The design and reinforcement of these portions of the structure are exactly the same as already described under the heads of Beams and Floors.* The girders and deck slab, being applied and intended to work together, are considered as constituting a series of T-beams.

Type A1.—Trestle bridge, a variation of the girder type, built upon framed supports such as are embodied in some forms of pier and jetty construction (*q.v.*). The spans between the supports consist of longitudinal and transverse girders or beams, either straight or curved, connected by a deck slab.

Type B.—Arched girder bridge, consisting of two or more longitudinal girders with two sides parallel, the top flat and horizontal, and the under side with a concave profile; the longitudinal girders braced transversely if necessary by parallel-sided girders, and the whole connected by a deck slab.

Bridges of this type frequently have the appearance of genuine arches, the outer sides of the longitudinal girders giving the idea of arch ribs and spandril walls.

Speaking generally, the nature of the reinforcement is exactly the same as that described under the heads of Beams and Floors,† but the disposition of the main and secondary reinforcement is such that all arch thrust is taken up within the members, which are thus converted into self-contained trusses exerting no horizontal thrust against the abutments.

This mode of design when applied to the system results in what is termed Mouchel-Hennebique practice.

Type C.—Bowstring girder bridge, designed generally in accordance with the principles governing steel bridges of similar type, with tension and compression booms connected by latticed bracing composed of struts and ties.

The compression members are designed similarly to Columns,‡ due regard being given to transverse stresses. The tension members are reinforced in the same general way, sufficient longitudinal reinforcement being employed to guard against excessive tensile stress in the concrete.

Bridges and girders of this type also represent Mouchel-Hennebique design.

Type D.—Arch bridge, comprising two or more arch ribs, springing from skewbacks with which they are monolithically connected. As the principle of articulation is not adopted in this system of reinforced concrete, the arch ribs are tapered from the springings to the crown.

Reinforcement is applied near the extrados and intrados for the resistance of tension as indicated by stress diagrams prepared in the usual way, and typical Hennebique stirrups are also included for resistance to shear and tension on diagonal planes.

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* Vol. II., No. 6, pp. 430 and 435; † Vol. II., No. 6, pp. 430 and 435; ‡ Vol. II., No. 6, p. 438.

Table VII.—Summary of the Chief Characteristics of various Systems of Reinforced Concrete Bridge Construction adopted in Great Britain.

No.	Name of System.	Type of Bridge.		
		Girder.	Cantilever.	Arch.
1	Coignet	(A) *Parallel Girder*, with longitudinal and transverse beam and deck slab (Reinforcement as in ***Beams*** and ***Floors***) (A 1) *Trestle Girder*.—As above but with framed supports reinforced as in ***Beams*** and ***Columns***	—	(B) Ribs reinforced by longitudinal bars at intrados and extrados and by diagonal or radial shear bars, solid or pierced spandrils carrying deck beams and slab
2	Considère	(A) *Parallel Girder*, with main and secondary beams and deck slab (B) *Bowstring Girder*, with lower boom reinforced by longitudinal bars, some bent up near supports; upper boom reinforced by spiral coil and longitudinal bars as in ***Columns***. Ties reinforced by straight bars and struts by spiral coils and straight bars	—	(C) Ribs reinforced by longitudinal bars and spiral coils, open spandrils with bracing, deck carried by longitudinal and transverse beams. Compression members reinforced by spiral coils and longitudinal bars, tension members by straight bars with provision for shear
3	Expanded Metal	(A) Girders reinforced by longitudinal tension bars, strips of expanded metal as shear reinforcement Decking reinforced by expanded metal sheets (B) Rolled steel or built-up steel girders Decking reinforced by expanded metal sheets carried round the girders	—	—
4	Hennebique	(A) *Parallel Girder*, with longitudinal and transverse beams and deck slab Reinforcement as in ***Beams*** and ***Floors*** (A 1) *Trestle Girder*, as above but with framed supports reinforced as in ***Beams*** and ***Columns*** Girders either parallel or arched (B *Arched Girder*, with curved longitudinal girders, sometimes braced by transverse parallel beams and connected by deck slab. Monolithic throughout Reinforcement as in ***Beams*** and ***Floors*** (C) *Bowstring Girder*, with tension and compression booms connected by ties and struts reinforced similarly to ***Columns***	(E) Solid or latticed cantilever ribs connected by transverse beams and deck slab Reinforcement as in ***Beams*** and ***Floors***	(D) Ribs reinforced by longitudinal bars at intrados and extrados and by diagonal stirrups, solid or open spandrils and cross walls carrying deck beams and slab
5	Indented bar	(A) Main and secondary beams and deck slab, or solid slab of uniform thickness without beams Reinforcement as in ***Beams*** and ***Floors***	—	(B) Ribs reinforced by longitudinal bars at intrados and extrados, transverse bars and diagonal or radial shear bars. Solid or pierced spandrils for support of decking.
6	Kahn	(A) *Longitudinal Girders*, transverse beams where required and deck slab. Reinforcement as in ***Beams*** and ***Floors*** (A 1) *Trestle Girder*, as above but with framed supports reinforced as in ***Columns*** and ***Beams***	(C) Cantilever ribs connected by small transverse beams and deck slab Reinforcement as in ***Beams***	(B) Ribs reinforced by Kahn bars at intrados and extrados with shear wings projecting diagonally. Cross bars at the crown for distributing stresses

Upon the arch ribs are built either monolithic spandril walls or isolated columns supporting spandril arches, the walls or arches being connected either by cross walls or beams, and these in turn connected by a continuous deck slab.

Type E.—Cantilever bridge, built of solid or latticed cantilevers connected laterally and completed by a deck slab, the details of reinforcement as described under the heads of BEAMS and FLOORS,* and disposed in accordance with the distribution of stresses determined in the customary manner.

Cantilever bridges on this system are sometimes designed with the external form of arches, and only distinguishable from such structures by consideration of the principles of construction actually embodied. In a cantilever bridge of the form now in question, what appears to be a genuine arch is regarded as two cantilevers, one projecting from either side, and whose weight is usually balanced by an outer span suitably anchored; the roadway forms a tension member for each pair of cantilevers.

(5) Indented Bar System.—*Type A.*—Girder bridge, having spans formed of main and secondary beams and a single deck slab, or consisting of a solid slab of uniform thickness. In either case the concrete is reinforced in general compliance with the methods described under the heads of BEAMS and FLOORS.†

Type B.—Arch bridge, usually comprising an arch rib continued from side to side of the span and calculated as an arch fixed at the abutments. The reinforcement consists of longitudinal bars near the intrados and extrados, transverse bars, and diagonal or radial shear bars at suitable distances apart.

Upon the arch rib are carried spandril walls or a series of arches for the support of the road platforms, the whole work being monolithic and reinforced in the manner described under the heads of BEAMS,‡ WALLS,§ and FLOORS.||

(6) Kahn System.—*Type A.*—Parallel girder bridge, including two or three longitudinal girders with transverse beams where required and continuous deck slab. These members are designed and reinforced on the same principles as Kahn system beams and floors.¶

Type A1.—Trestle bridge, including ordinary girder spans supported by framed trestles comprising columns and bracing reinforced in accordance with the distinctive principles described under the heads of COLUMNS and BEAMS.**

Type B.—Arch bridge, consisting of two or more arch ribs connected as required by transverse members, or of an arch extending across the whole width of the bridge and having continuous or open spandrils for support of the decking.

Bridges of this type are usually treated as arches fixed at the abutments and designed in accordance with the theory of the elastic arch by an adaptation of the method proposed by Professor Charles E. Green.

The reinforcement consists of Kahn bars placed near the intrados and extrados, with the shear wings projecting diagonally upwards and downwards producing a latticed effect. At the crown of the arch, where there is little filling, the effect of concentrated loads is met by cross bars acting as distributors of stress over the entire width of the arch. The construction is monolithic throughout.

Type C.—Cantilever bridge, consisting of cantilever ribs springing from abutments or piers and connected at the middle of each span. The cantilevers are joined transversely by small beams and a continuous deck slab. The system of reinforcement is practically identical with that adopted in the case of BEAMS.††

An advantage claimed for this form of design over arch construction is the large saving effected in the abutments.

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* Vol. II., No. 6, pp. 430 and 435; † Vol. II., No. 6, pp. 431 and 436; ‡ Vol. II., No. 6, pp. 431 and 436; § Vol. II., No. 6, p. 440; || Vol. II., No. 6, pp. 431 and 436; ¶ Vol. II., No. 6, p. 437; ** Vol. II., No. 6, pp. 439 and 432; †† Vol. II., No. 6, p. 432.

QUAYS, JETTIES AND PIERS.

(1) Coignet System.—Quays, jetties, and piers on this system usually comprise round or square piles, reinforced as described under the head of Piles,* supporting a superstructure of columns, bracing, beams, and a continuous deck slab.

Sometimes the piles and columns at the back are connected by panels of reinforced concrete (with or without projecting counterforts), acting as retaining walls for the earth behind, and in some cases the front and ends of the structure are enclosed in a similar manner, providing chambers which can be employed for the installation of machinery or used for storage purposes.

Table VIII.—Summary of the Chief Characteristics of Various Systems of Reinforced Concrete Quay, Jetty, and Pier Construction adopted in Great Britain.

No.	Name of System.	Foundation.	Superstructure.	Special Details.
1	Coignet.	Reinforced concrete piles (*q.v.*)	Columns with bracing carrying longitudinal and transverse beams, and deck slab. Reinforced as ***Columns, Beams*** and ***Floors***	Piles and columns at back, sometimes connected by panels with or without counterforts forming retaining walls. Front, back, and ends sometimes filled in to form interior chamber
2	Considère.	Reinforced concrete piles (*q.v.*)	Columns, walings, bracing, deck beams, and deck slab. Reinforced in ***Columns, Beams*** and ***Floors***	—
3	Hennebique.	(A) Solid reinforced concrete piles (*q.v.*) or Mouchel hollow reinforced concrete piles (*q.v.*) (B) Mouchel cylinder piers of large diameter	Columns, walings, bracing, deck beams, and deck slab. Reinforced as ***Columns, Beams*** and ***Floors.*** As above, but with fewer bracing members	For quays and wharfs sheet piles are sometimes driven between the foundation piles to form a water-tight retaining wall at the back of the structure. Quay walls are sometimes built of sheet piling with a row of foundation piles behind, forming a water-tight foundation for a superstructure
4	Indented Bar.	Mass concrete reinforced by vertical bars near front surface	Mass concrete reinforced by vertical and horizontal bars near front surface. Counterforts where required are reinforced and tied to the wall by horizontal bars	—
5	Williams.	Piles reinforced by rolled steel sections	Columns, beams, and decking reinforced by small rolled steel sections; hoop steel lacing in the beams	—

(2) Considère System. — An example of this system coming under the present heading is a jetty on the Thames having foundation piles driven in pairs and surrounded above the bed of the sea with concrete moulded in the form of cylindrical columns and connected above low-water level by walings. On the foundation thus formed rises a superstructure consisting of columns, bracing, deck beams, and a continuous deck slab.

The various elements of the construction are reinforced in the typical manner described under the heads of Piles, Columns, and Beams.†

(3) Expanded Metal System. — Expanded steel has been used for reinforced concrete quay decking. It is claimed that, owing to its peculiar formation, the material is particularly adapted for this class of work, for the locking of the concrete within its meshes is most efficiently achieved and a mechanical bond is obtained such as cannot be surpassed, and thus the concrete is not liable to crack or splinter under shock or vibration.

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* Vol. II., No. 6, p. 442; † Vol. II., No. 6, pp. 442, 438 and 430.

(4) ***Hennebique System.***—Structures of the class now under consideration are of two main types: (a) founded on solid piles, or hollow diaphragm piles, with a framed superstructure comprising columns, walings, bracing, deck beams, and deck slab; and (b) founded wholly or partly on Mouchel cylinder piers of large diameter, by which it is claimed that great rigidity is secured without so much bracing as is required in connection with ordinary piles, and having similar piers in the superstructure.

The system of reinforcement for the various elements of types (a) and (b) is virtually as described under the heads of PILES, COLUMNS, BEAMS, and FLOORS.*

The piers employed in type (b) consist of piles driven in groups, each enclosed above the bottom of the river, dock, or harbour by a reinforced concrete cylinder, and the interior space filled in with reinforced concrete so as to constitute a solid pier. The inner surface of each cylinder is left rough, in order to provide a good tooth for the filling concrete. Ties and struts are connected with the piers by moulding their ends in holes cut in the side of the piers, and beams are moulded where required upon the top of the piers with due provision for the anchorage of the reinforcement.

In the case of quays and wharves, sheet piles are frequently driven between the foundation piles, forming a water-tight wall to enable earth to be filled in at the back of the structure and maintained at the desired level.

Quay Walls are sometimes built on the Hennebique system by driving a row of sheet piles along the water front, with foundation piles in one or two rows at a short distance behind the sheet piling. The three rows of piles are then connected by longitudinal and transverse beams and a continuous slab which forms the foundation for a superstructure of the retaining wall type,† the whole of the work being monolithic and reinforced in the usual manner.

(5) ***Indented Bar System.***—Quay walls built on this system in Great Britain are in mass concrete reinforced by vertical and horizontal bars near the front surface, with horizontal bars along the top of the wall at the front and back. The walls are strengthened by the addition of counterforts where required, these also being reinforced and tied to the walls by horizontal bars.

It is claimed that this method of construction effects a considerable saving in the mass of concrete, and that the mechanical bond afforded by the indented bars is particularly suitable in structures where the concrete is exposed to the action of sea water, which the patentees consider has a tendency to impair the efficiency of the natural adhesion between the concrete and the steel.

(6) ***Williams System.***—For jetties, wharves, and piers, piles on this system can be employed for the foundations, the superstructure consisting of rolled steel joists surrounded with concrete. Small steel joists surrounded with concrete are used for the tension members in beams, and the beams are provided with verticals of round steel fish-tailed at the ends to take the shearing strains. The decking consists of very small joists laid in concrete at suitable intervals, with hoop-steel lacing alternately above and below them at right angles.

The idea of forming a deck or floor in the above manner is not new, but it gives very good results, and is preferred to any other by the proprietors of the Williams system. Struts and braces have a joist in each angle and horizontal as well as vertical fish-tailed rods. The advantages claimed for the use of joists instead of bars are that owing to their relative stiffness, they are more easy to manipulate, are cheaper, and have far more surface in contact with the concrete than ordinary bars.

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* Vol. II., No. 6, pp. 412, 438 and 435; † Vol. II., No. 6, p. 440.

Sometimes columns are mounted on groups of piles, when girders of considerable span become necessary.

The typical character of the Williams construction is described under the heads of BEAMS and PILES.*

WATER RESERVOIRS.

(1) Coignet System.—Reservoirs and water tanks are constructed on this system of any required shape.

Table IX.—Summary of the Chief Characteristics of Various Systems of Reinforced Concrete Water Reservoir Construction adopted in Great Britain.

No.	Name of System.	Rectangular.	Cylindrical.
1	Coignet	Walls stiffened by columns and counterforts. Built with or without cover. Reinforcement as in ***Walls, Columns, Beams*** and ***Floors.***	Walls designed similarly to ***Pipes.*** Built on ground, or as water towers supported either on columns or on circular walls forming an interior chamber.
2	Expanded Metal	(A) Open Reservoir on foundation slab: walls with or without counterforts and reinforced by sheets of expanded metal near outer surface or both surfaces. (B) Covered Reservoir similar to type A, but with roof carried on steel columns embedded in concrete; steel roof beams also embedded in concrete, or by reinforced concrete columns and beams. Roof slab reinforced by expanded metal sheets.	—
3	Hennebique	(A) Open Reservoir on foundation slab, walls built as panels between columns and counterforts and finished at top by coping beams. (B) Covered Reservoir similar to type A but with interior columns supporting main and secondary roof beams connected by roof slab. Reinforcement as in ***Walls, Columns, Beams*** and ***Floors.***	(C) With or without cover and built on a general foundation slab, the walls being designed similarly to ***Pipes.*** Roof supports, where required, consist of reinforced concrete columns (q.v.) and the roof is similar to a floor (q.v.) (D) Elevated Reservoir similar to type C but supported on framework usually consisting of columns with or without bracing.
4	Indented Bar	Founded on general slab with independent piers, if required, by nature of soil. Walls consist of vertical slabs with counterforts. Roof, where added, receives intermediate support from columns. Reinforcement as in ***Beams, Floors, Columns*** and ***Walls.***	Open or enclosed with walls reinforced by vertical bars and horizontal rings. Elevated reservoirs built on framework or circular walls forming interior chamber.
5	Kahn	Built on foundation slab with walls stiffened by columns or counterforts, and with or without roof. Reinforcement as in ***Walls, Columns, Beams*** and ***Floors.***	Built on foundation slab or on elevated structure. Reinforcement as in ***Walls, Columns, Beams, Floors*** and ***Pipes.***

For rectangular reservoirs the walls are stiffened by columns or counterforts, and for cylindrical reservoirs the walls are designed on principles akin to those governing the construction of pipes.

Elevated water reservoirs on the Coignet system have been built with supporting columns, or upon cylindrical walls enclosing a chamber which can be used for pumping machinery, stores, or other purposes.

The general characteristics of the reinforcement are as described under the heads of BEAMS, FLOORS, WALLS, COLUMNS, and PIPES.†

(2) Expanded Metal System. — *Type A.*—Open reservoir, built up from a general foundation slab with extended footings beneath the walls, which are made with or without counterforts, according to circumstances. The whole construction is reinforced by sheets of expanded metal laid near the outer surface of the concrete, with a second system of reinforcement near the inner surface if upward or inward pressure is likely to occur on the floor or walls.

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* Vol. II., No. 6, pp. 434 and 443; † Vol. II., No. 6, pp. 429, 434, 437 and 442.

Type B.—Covered reservoir, generally similar to *Type A*, but provided with interior columns consisting of rolled steel sections embedded in concrete, and with roof beams formed by rolled steel joists covered with concrete, or by cambered steel channel and concrete arch ribs, or with interior columns and beams of reinforced concrete, the roof slab itself being of concrete reinforced by sheets of expanded metal, applied as described under the head of FLOORS.[*]

(3) Hennebique System.—*Type A.*—Open storage reservoirs, comprising a general foundation slab, stiffened by beams and footings in the form of beams, and walls built with panels between columns and counterforts. The walls are finished at the top by coping beams.

The various elements of the construction are reinforced in accordance with the principles previously described under the heads of BEAMS, FLOORS, COLUMNS, and WALLS.[†]

Type B.—Covered service reservoir, similar to *Type A*, but with the addition of columns having extended bases (which rest upon, and are moulded with, the foundation slab) supporting a system of main and secondary beams connected by a continuous roof slab. For particulars of construction see COLUMNS and FLOORS.[‡]

Type C.—Cylindrical reservoirs, made with and without cover, the latter being designed in the same manner as a floor, with or without intermediate support, according to the span.

Reservoirs of this class are built up from a general foundation slab as described under the head of *Type A*, and their walls are reinforced with a special view to the resistance of outward pressure. Consequently the general idea of the reinforcing network is akin to that described under the head of PIPES.[§]

Type D.—Elevated reservoirs are similar in construction to those of *Type C*, save that the reservoir proper is supported upon framework usually consisting of columns with or without bracing, according to height and load.

(4) Indented Bar System.—Open and covered rectangular reservoirs on this system are founded upon a general slab, with independent piers or footings if required by the unstable nature of the soil. The walls are built of vertical slabs with counterforts at intervals, and in cases where a roof is added, columns are provided as intermediate supports.

The general character of the reinforcement is the same as that described under the heads of the members— BEAMS, FLOORS, COLUMNS, and WALLS.[||]

Water towers on the Indented Bar system can be built either open or enclosed, the latter being a convenient and economical method in cases where the interior space is useful for administration purposes.

The outer walls of towers built in this form are reinforced by vertical bars spaced 18 in. to 24 in. apart, and by horizontal rings of bars. The size of bars used depends on that of the structure.

The foundations, floors, and other details are reinforced in the manner already described.

(5) Kahn System.—Reservoirs on this system can be constructed of any required shape or dimensions, and supported either on the ground or upon an elevated structure.

The method of design is similar to that embodied in the elementary forms of BEAMS, FLOORS, WALLS, and COLUMNS.[¶]

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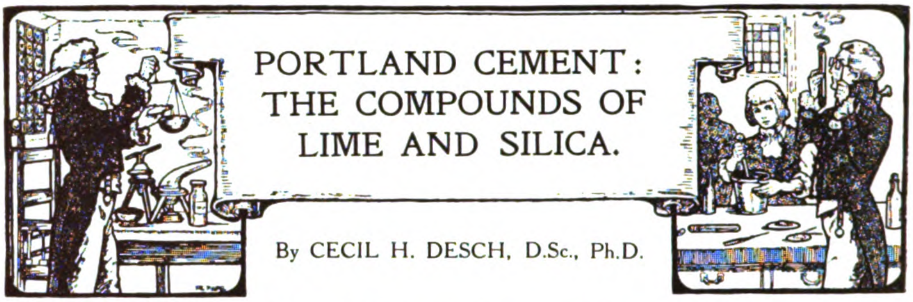
[*] Vol. II., No. 6, p. 435; [†] Vol. II., No. 6, pp. 430, 435, 438 and 440; [‡] Vol. II., No. 6, pp. 438 and 435; [§] Vol. II., No. 6, p. 442; [||] Vol. II., No. 6, pp. 431, 436, 438 and 440; [¶] Vol. II., No. 6, pp. 432, 437, 441 and 439.



PORTLAND CEMENT: THE COMPOUNDS OF LIME AND SILICA.

By CECIL H. DESCH, D.Sc., Ph.D.

We are glad to be able to publish a further contribution under this heading, so closely allied to that of the constitution of Portland Cement; a subject which is still receiving the closest attention of eminent authorities more particularly in cement making countries.

The question is one of theoretical rather than practical interest, inasmuch as the cement produced by the modern methods of to-day—even though a definite and acceptable explanation cannot yet be given of the chemical and physical phenomena involved—is of such excellent quality, that explanation rather than improvement is likely to be the ultimate outcome of these investigations. It is fortunate that the Engineer has not to wait for the results of these scientific researches to satisfy himself of the quality, utility, and excellence of the material he uses, as it would appear that some considerable time yet may elapse before this most difficult chemical and physical problem is solved.—ED.

In discussing the question of the chemical constitution of Portland cement in former issues of this Journal (CONCRETE, 1906, vol. i., pp. 40, 101, 258), the writer suggested that the obscure questions as to the nature of the compounds actually present in cement clinker could be best studied by the freezing-point method. This method, which has yielded such valuable results in the examination of metallic alloys and mixtures of fused salts, consists in the examination of a series of mixtures of the components in progressively varied proportions. Each mixture is melted, and the melting and freezing points observed by means of a suitable pyrometer. A curve constructed from the data thus obtained shows the variation of freezing and melting point with composition. If the apparatus is so designed that any evolution of heat in the solid state may also be observed, much more information may be obtained. The complete equilibrium diagram constructed in this way shows the temperatures at which the transformation of one form of a solid constituent into another takes place, and the way in which such a transformation temperature changes with the varying composition of the mixtures.

When a stable compound of the two components is formed, the fact is usually indicated by a maximum on the freezing-point curve, so that the addition of either constituent to the compound has the effect of lowering the freezing point. (Under perfect conditions, freezing point and melting point would be identical, but owing to viscosity and other causes this is frequently not realised in practice. In working with metallic alloys, it is always the freezing point which is measured; in rocks and mixtures of silicates, however, there are often advantages in determining the melting point.) The vexed question, then, as to the number and composition of the compounds which lime forms with silica should be elucidated by a careful study of the freezing-point curve of such mixtures, and by a search for maxima or breaks in the direction of such a curve.

The experimental difficulties of such an investigation are, however, very great. There is, first, the difficulty due to the high temperatures involved, ranging up to 2,200° C. (4,000° F.) and more. Very few materials resist such a temperature, and the problem of constructing furnaces and crucibles suitable for the experiments therefore calls for great ingenuity in its solution. Then, again, the ordinary pyrometers become unavailable long before 2,000° C. is reached, even platinum thermo-couples being melted. Add to this the high viscosity of the molten silicates, and their tendency to pass from the liquid to the vitreous state without any abrupt transition, which could be recorded by a pyrometer, and it will be understood that investigators in this department of chemistry have been confronted with no easy task.

Shortly after the papers mentioned above were written, an exhaustive study of the lime-silica series was published by Messrs. A. L. Day and E. S. Shepherd, of the Carnegie Institution, in Washington. These authors devised suitable apparatus as the result of experience gained in the same laboratory in working with felspars and other silicates. For the highest temperatures, iridium was found to be the only material available for the furnace and crucible. The temperatures were measured by means of an optical pyrometer, depending on the comparison of the radiation from the heated crucible with that of an incandescent filament, previously calibrated.

Two years ago, Boudouard communicated a paper to the Iron and Steel Institute, in which a freezing-point curve was given for the lime-silica series, several maxima, indicating the existence of compounds, being recorded. In Boudouard's experiments, the temperature was measured by means of the Seger cones employed in pottery kilns, etc. These are, however, entirely untrustworthy for such a purpose. When a Seger cone contains a small quantity of an easily fusible constituent, softening and deformation of the cone may take place in time, even though the greater part of the mass may be made up of much less fusible material. For this reason Seger cones are useless for experimental research, although they are of service in the comparative measurements required in technical practice.

Messrs. Day and Shepherd were not able to investigate the mixtures of lime and silica throughout their whole range. Mixtures extremely rich in silica are so viscous that no arrest in the cooling can be observed. At the other extremity of the series, pure lime is readily melted in the electric arc, but the temperature is so high that no satisfactory measurement of it has yet been made. But between these two limits, mixtures varying through a considerable range of composition were studied. It may be said at once that only two compounds of lime and silica were found to be produced in solidification from the molten state—namely, the metasilicate, CaO,SiO_2, and the orthosilicate, $2CaO,SiO_2$. The results obtained were such as to exclude the possibility that any other definite compounds were formed.

The metasilicate, CaO,SiO_2 does not occur in Portland cement clinker. It occurs in Nature as the mineral wollastonite, and is found in a hydrated form in Portland cement after setting. It exists in two modifications, of which one, the α-metasilicate, or pseudo-wollastonite, separates from the melt, changing into the stable β-metasilicate, or wollastonite, at a little below 1,200° C.

The orthosilicate, $2CaO,SiO_2$ is not found in Nature, but has often been prepared artificially by fusing finely-ground mixtures of the two components. It solidifies at 2,082° C. to a mass of monoclinic crystals of specific gravity 3·27. This -modification is, however, unstable, and on cooling to 1,410° readily passes into orthorhombic crystals of the β-modification, which has about the same specific gravity, so that the conversion takes place without notable change of volume. At 645° a further change takes place. The stable modification then produced, the γ-orthosilicate, forms monoclinic crystals, and has the remarkably low specific gravity of 2·97. Consequently the change from β to γ is accompanied by an increase of volume of about 10 per cent., and the result is that the mass spontaneously falls to powder. This is the cause of the well-known "dusting" which occurs in cements and slags, approximating to the constitution $2CaO,SiO_2$. This disintegration is the more complete the more nearly this composition is approached.

Since the work of Le Chatelier, the essential constituent of Portland cement has been assumed by most writers on the subject to be a tricalcium silicate, $3CaO,SiO_2$. Newberry, Richardson, Schott, and others, have prepared substances of this composition which have been described as homogeneous, but the optical properties of these mixtures are such that it has hitherto been very difficult to decide as to their homogeneity, or otherwise, by microscopical examination. Messrs. Day and Shepherd's pyrometric experiments do not confirm the existence of the tricalcium silicate. They found orthosilicate to be present in all mixtures up to 90 per cent. of lime, and no evidence of any other compound was found. These results were confirmed by an exhaustive optical investigation. The ordinary method of grinding thin sections of clinker and examining them in Canada balsam is faulty, owing to the overlapping and interlacing of the crystals, and the authors in this case abandoned it in favour of the examination of the powdered substance in liquids of different refractive indices. Tested in this way, mixtures approximating to the composition of the tricalcium silicate proved in all cases to be mixtures of the orthosilicate with free lime. The same was found to be the case with the artificial Portland cement silicate prepared by Dr. Clifford Richardson.

This result may appear to be inconsistent with what is known as the chemistry of Portland cement, it being a generally accepted statement that the presence of free lime is fatal to the quality of the cement. Much, however, turns on the meaning to be attributed to the term "free" lime. The addition of ordinary quicklime to cement undoubtedly causes expansion and cracking to take place after setting. But lime which has been fused in the electric arc reacts only very slowly with water, and the effect of mixing such hard, crystalline lime with the silicate does not seem to have been examined. It may be that an excess of lime in Portland cement clinker is only dangerous because the temperature of the kiln is insufficient to bring about its fusion, so that the lime remains in an active form. But it is difficult to reconcile Messrs. Day and Shepherd's results with what is known as to the proportions of lime and silica in artificial Portland cements which give the best results on setting. Schott, in a paper published last year, in the *Tonindustrie-Zeitung*, claims to have found that mixtures of the composition of a tricalcium silicate exist in two forms, one of which hardens well with water, whilst the other readily disintegrates and has no hydraulic properties. His mixtures do not appear to have been heated to so high a temperature as that employed by the American workers, but the heating may have been continued for a longer time. It is conceivable, knowing what we do of the slowness with which chemical reactions take place in such viscous systems, that further combination might take place on prolonged heating, although no evidence of it was obtained during the freezing-point experiments. Such cases have been observed quite recently in the study of certain metallic alloys.

The application of Messrs. Day and Shepherd's results to the chemistry of Portland cement must therefore be made with some caution. In commercial clinker, the aluminates present may modify the conditions very considerably, although the addition of certain fluxes to the lime-silica mixtures was found by the authors to be without influence on the equilibrium. But the lime in excess of that required to form the orthosilicate may conceivably be held in a state of solid solution, not by the silicate, but by the aluminate, so losing its property of causing expansion on setting. The question is far from being solved at present, but the extension of metallurgical and mineralogical methods to its study, as here described, undoubtedly points the way to a solution.

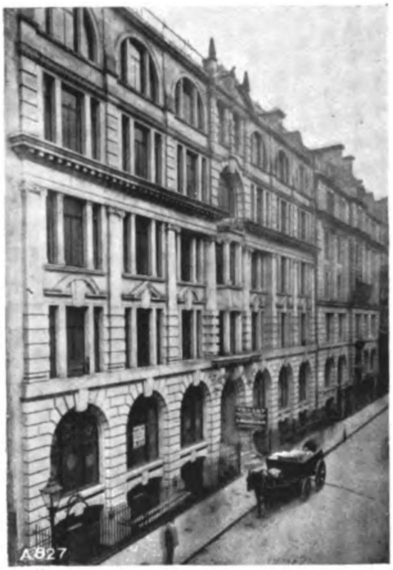
A REINFORCED CONCRETE OFFICE BUILDING IN LONDON.

"FRIARS HOUSE," BROAD STREET, E.C.

We are presenting herewith particulars of some City premises constructed mainly in reinforced concrete.

Where the plan of an office building is free from complication and difficult angular features, it will generally be found that reinforced concrete is economical.

Besides showing drawings, we are presenting two illustrations of the work in course of actual execution.—ED.



"Friars House." Front Elevation.

The office buildings recently erected by Messrs. Holland & Hannen, of London, known as "Friars House," Broad Street, offer an interesting example of modern methods of construction. It is, we believe, one of the first modern buildings in the City of London to be erected without the aid of structural steel of any kind; in fact, there is not a single rolled steel joist in the building.

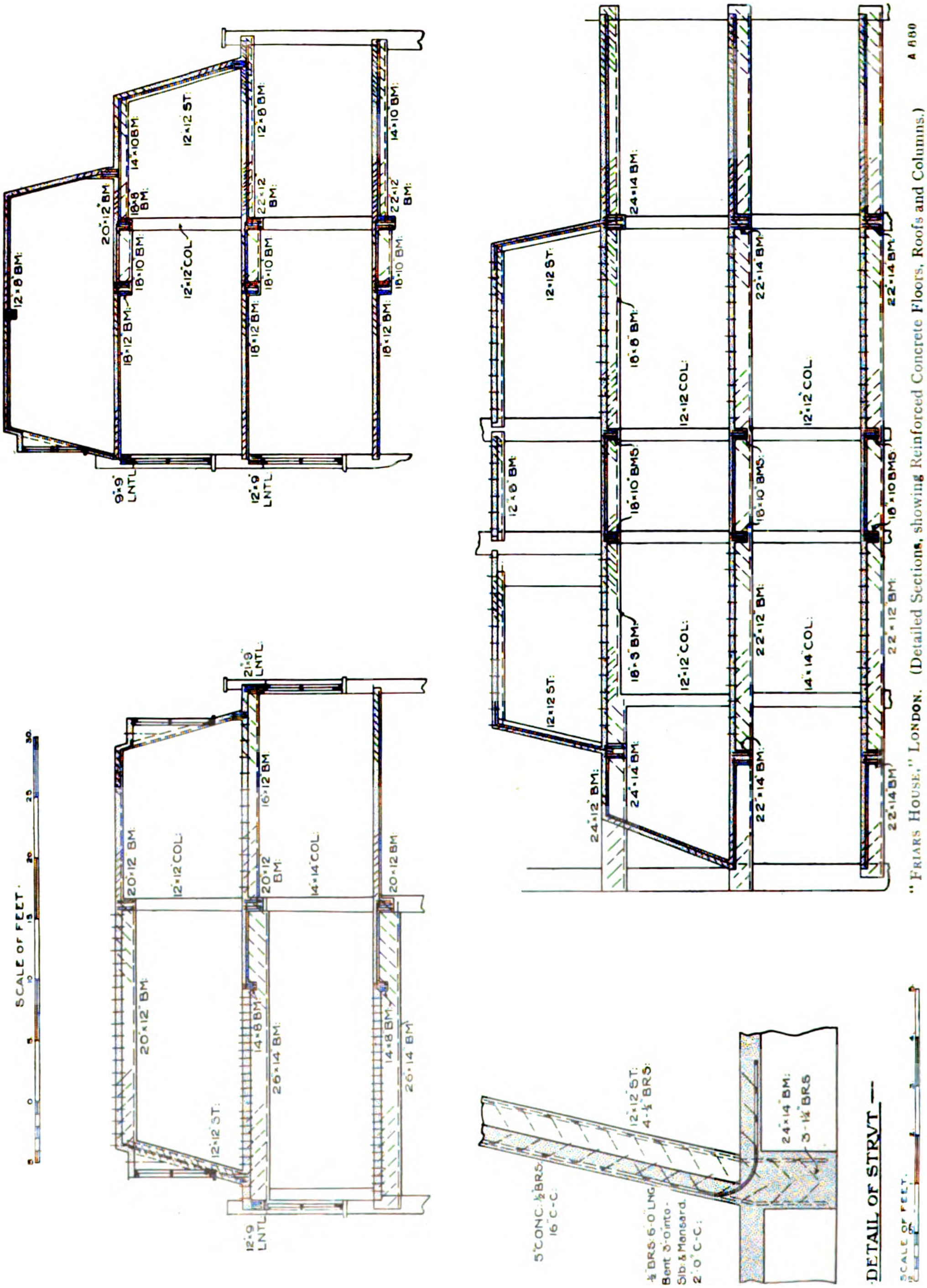
The front elevation in Portland stone is shown in the heading. It is in the Renaissance style and of some architectural pretension, and Mr. Arthur Blomfield, F.R.I.B.A., was the architect.

In settling upon the type of construction adopted, it should be mentioned that Messrs. Holland & Hannen, who were not only the general contractors, but the owners of the building, required rapidity of erection, so that their investment might produce revenue at the earliest possible moment; and bearing this in mind, it is certainly of interest that reinforced concrete was adopted.

DESCRIPTION.

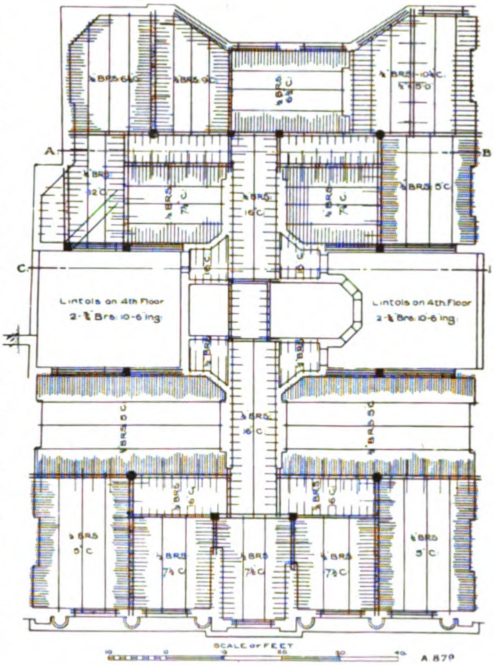
The building has a frontage of 77 ft. and a depth of 107 ft. There are eight floors, approximating in area 7,000 sq. yds., and the whole of the stanchions, girders, beams, and floor slabs of these, together with the flat roof, mansard, caretaker's quarters, staircase, and lintels throughout, were constructed *in situ* on the Kahn system. The time occupied was six months, but we are assured that with a clear run a much shorter period would have sufficed, the work being repeatedly held up by bricklayers and masons.

The concrete was hand-mixed, twice dry and twice wet, and composed of one part "Ferrocrete" Portland cement, two parts washed Thames sand, and three parts Thames ballast, crushed to pass a ¾ in. mesh. This mixture was cast moderately wet and gave a most satisfactory result.



DETAIL OF STRVT.

"FRIARS HOUSE," LONDON. (Detailed Sections, showing Reinforced Concrete Floors, Roofs and Columns.)

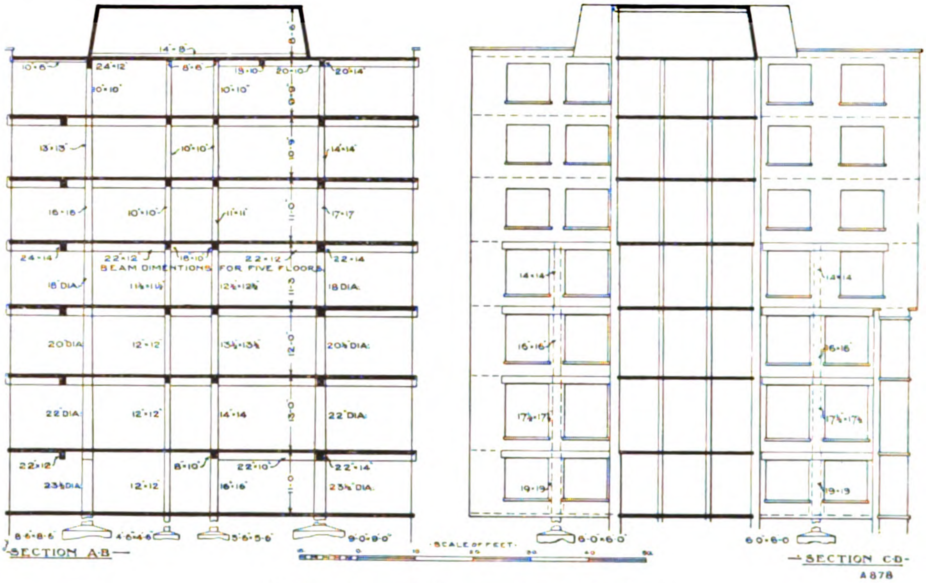


"FRIARS HOUSE," LONDON. (General Plan showing application of reinforcement.)

The four main columns in basement, designed to carry 200 tons, contain six ¾ in. Kahn bars, all sheared one way, are spirally wound with 1 in. by ⅛ in. good steel at a 4 in. pitch, the bars lapping into the column above. They are indicated round on plan. Other columns contain four Kahn bars wound with ⅛ in. steel wire. The main girder in each of the front bays has a clear span of 23 ft. 6 in., and floors of 16 ft. 6 in. and 17 ft. spans without beams will be noticed, the slabs being 7 in. thick reinforced with ½ in. Kahn bars. Shorter spans are carried by 5 in. and 6 in. slabs, and none are thicker than the 7 in. just mentioned. The continuity bars inverted over beams give continuous beam action, their shear members reaching downward into the slab on either side. At the springing of the mansard from the flat roof, anchor bars were embedded bonding the two together. The concrete walls of the first are 6 in. thick and of the second 5 in. thick, both reinforced with ½ in. bars on 16 in. centres. This interesting roof is illustrated in the drawings and photographs. The staircase was cast *in situ*, each flight treated as a beam, with bearings on corridor and landing, and reinforced with four ½ in. Kahn bars; a very simple and adequate method of construction.

Thus it will be seen that beyond the necessary joinery there is nothing here to feed a fire, and the owners feel that by eliminating all steel stanchions, girders, joists, etc., they have a building in which it is unlikely that sufficient heat would be

"FRIARS HOUSE," LONDON. (Reinforced concrete roof in course of construction.)

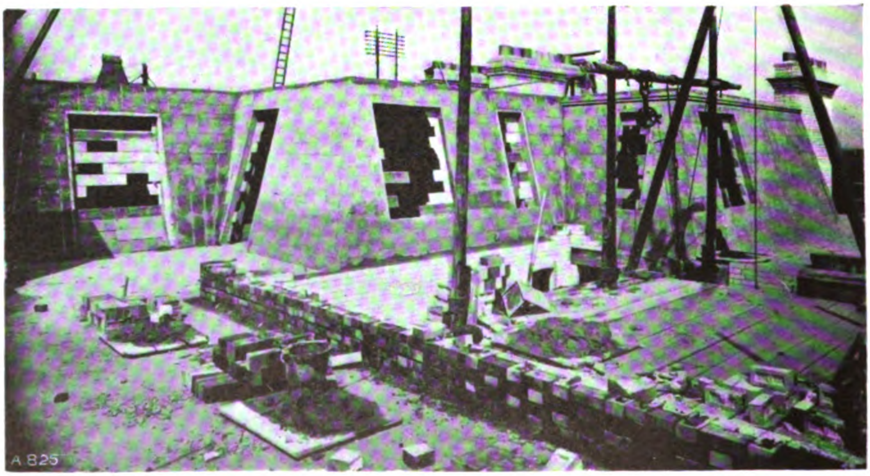


"FRIARS HOUSE" LONDON. (General Sections.)

generated, in the event of a fire, to cause material damage to the carcase of the structure.

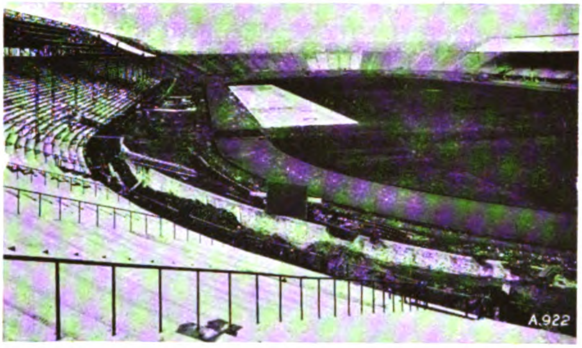
The live load provided for is 150 lbs. per sq. ft. An informal test was administered to a part of the front left half bay (23 ft. 6 in. span) within a month of concreting, and when the centering, except the usual supports, had been removed, 150 tons of sand and bricks were dumped on this floor, which proved upon examination afterwards to have suffered no damage.

An important item of economy, not to be lost sight of in connection with this erection, was that the usual "Scotchman" was dispensed with, there being no heavy members to lift; all materials were raised by a small electric hoist, a very considerable saving in itself.



"FRIARS HOUSE," LONDON. (Another view of the reinforced concrete roof in course of construction.)

THE REINFORCED CONCRETE STADIUM AT THE FRANCO-BRITISH EXHIBITION, 1908.



The Reinforced Concrete Stadium which has been erected in connection with the Olympic Games to be held at the Franco-British Exhibition is a structure of considerable technical interest, and as such we present particulars of it in the following pages, even before its entire completion.

As a combination of steel framing and reinforced concrete, it is certainly a unique example of its kind.—ED.

THE Stadium at the Franco-British Exhibition is an interesting erection from various points of view, for it is an excellent instance of how to employ framework of steel with platforms of reinforced concrete.

It was originally proposed to erect the entire structure in reinforced concrete (see *Fig.* 4), but apparently the question of demolishing it at the termination of the Exhibition caused the decision in favour of steel. We understand that there was practically no difference in the cost of the two forms of construction, though, if anything, reinforced concrete was the cheaper.

The design for the original structure was prepared jointly by the Patent Indented Steel Bar Co., Ltd., and the Empire Stone Co., Ltd., and the design finally adopted for steel was prepared by Mr. J. J. Webster, M.Inst.C.E., of Westminster. The structural work was carried out by Messrs. Alex. Findlay & Co., Ltd., of Motherwell, and the reinforced concrete platforms by the Empire Stone Co., Ltd., Thanet House, Strand, W.C.

It is obvious that reinforced concrete can be economically designed for this class of structure, as the risers for each seat or platform form girders between the main stringers, and act partly as T-beams.

The foundations are on ordinary concrete carried down to the firm ground some 6 to 10 ft. below ground level, as were the foundations for the majority of the buildings of the Exhibition, the greater part of the site consisting of made ground, as was shown by the terrible state of the Exhibition grounds after the rains of the past winter.

The view shown in *Fig.* 5 gives a plan of the whole structure. The total length of the Stadium is 10,000 ft. with a width of 600 ft. The total length round is practically half a mile, so that, as there are some thirty-two rows of platforms from back to front, it gives a total length of some sixteen miles of reinforced concrete platforms.

In regard to the steelwork, it is interesting to note that the channels shown in *Fig.* 3 are of 20 ft. span and are made continuous, thus reducing the cost. The total tonnage of steel used was 1,800 tons. An interesting feature is the columns supporting the roof. These surround the columns supporting the Stadium itself and act independently, although they rest on the same foundation. The chief reason for this was to enable a standard column for the whole of the Stadium to be adopted.

The columns consisted of two channels, $5\frac{3}{4}$ in. by $2\frac{1}{2}$ in., braced together with flats. The columns surrounding these consisted of four angles, 3 in. by 3 in., also braced together with flats. The Stadium itself is 75 ft. from front to back, and 36 ft. high

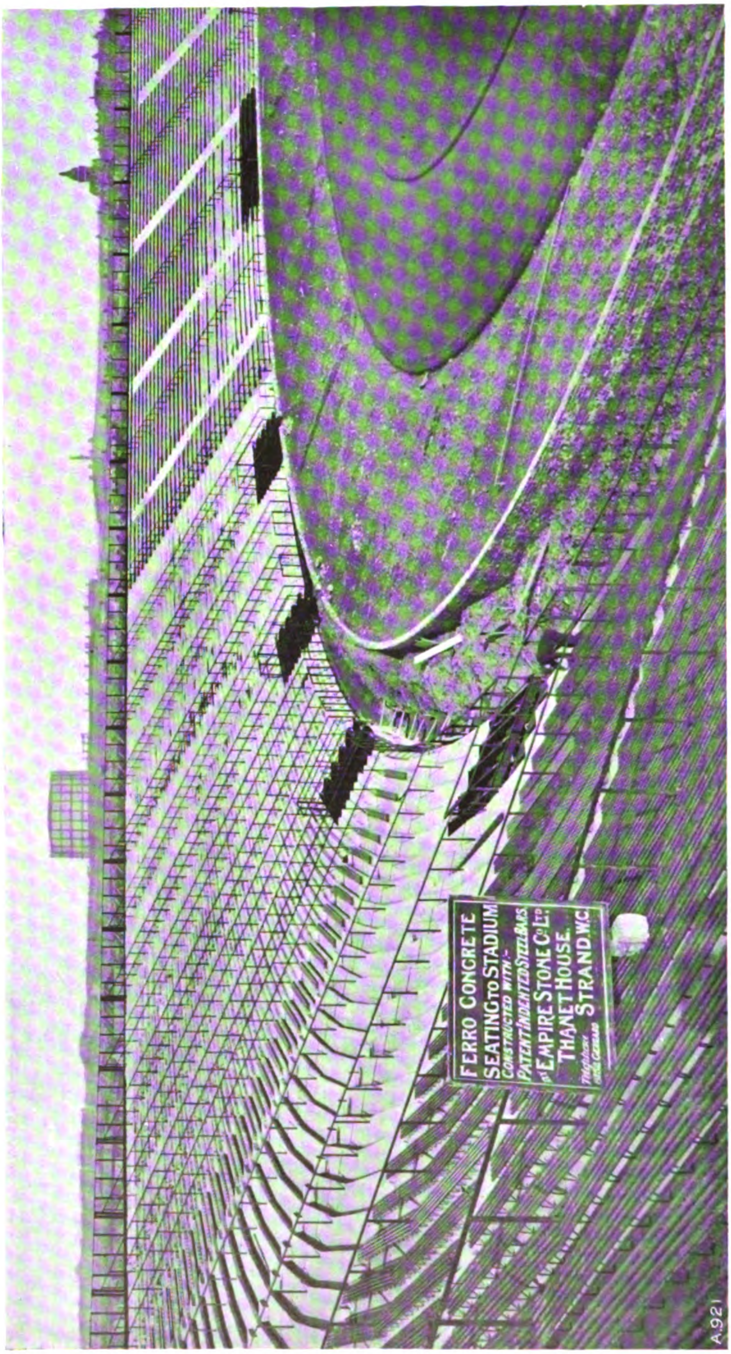


Fig. 1. The Reinforced Concrete Stadium at the Franco-British Exhibition nearing completion

at the back. The method of constructing the steel work was to adopt two large Scotch cranes, each mounted on four trucks. The work was then started at two points at once, and the cranes were able to command the whole width of the structure. Temporary lines were laid for the trucks to run upon.

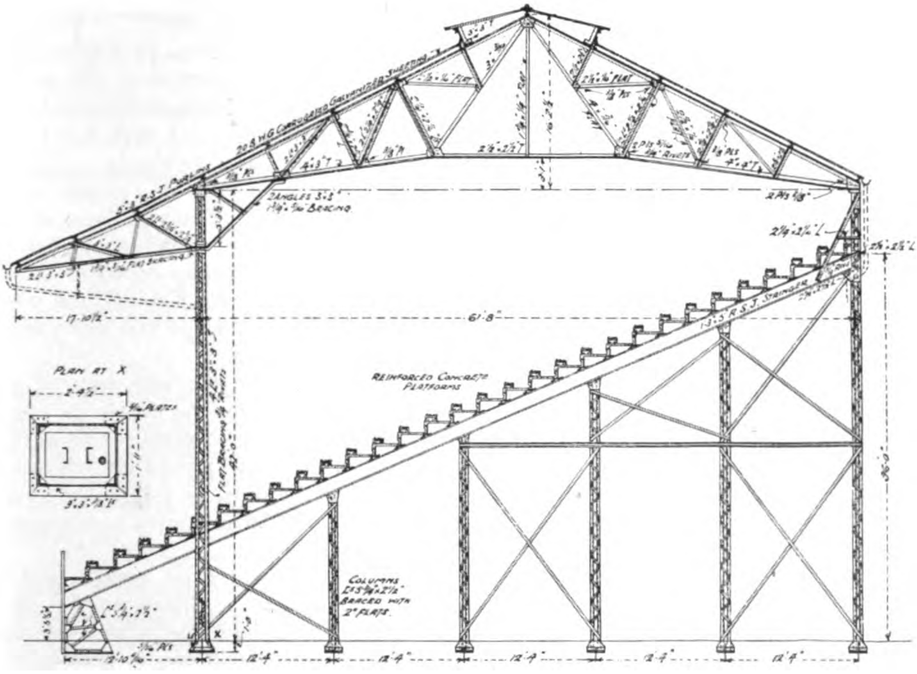
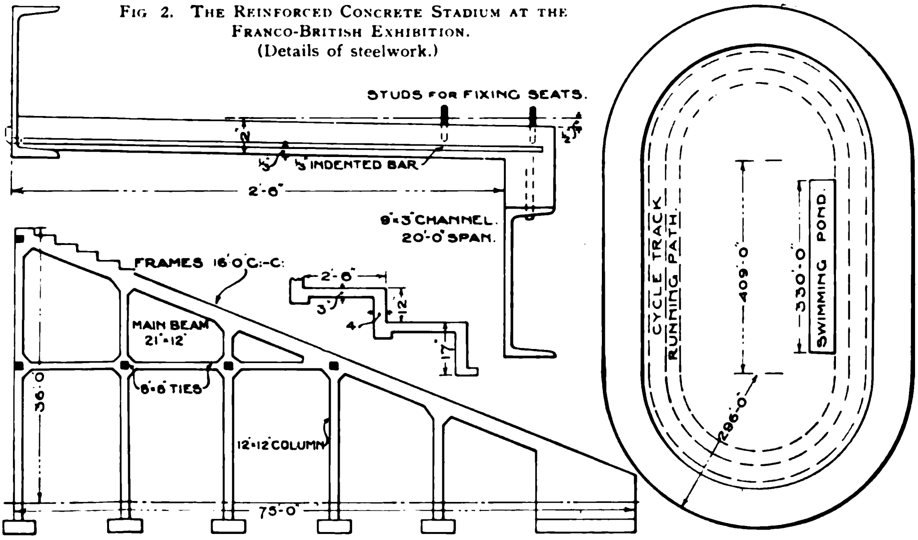


FIG 2. THE REINFORCED CONCRETE STADIUM AT THE FRANCO-BRITISH EXHIBITION. (Details of steelwork.)

FIG. 3

FIG. 4

FIG. 5



FIGS. 3, 4 & 5. THE REINFORCED CONCRETE STADIUM AT THE FRANCO-BRITISH EXHIBITION. (General plan, section of platform and superseded reinforced concrete design.)

The concrete for the reinforced concrete platform was placed in position by means of an inclined tramway running up the Stadium. The truck consisted of four platforms, so that, when stopped, each platform was opposite in line and level with the platform of the Stadium itself. The workmen were thus able to wheel the barrows direct on to the work. The centering for the concrete was all slung, and it is obvious that this was the only practical method of supporting it.

The concrete consisted of graded and crushed Thames ballast to pass ½ in. ring, with approximately 33 per cent. of sand, and mixed in the proportion of 1 to 4, and was all machine mixed. Although no special granolithic finish was arranged for, the whole of the seating has been finished in a satisfactory manner with the 1 to 4 mixture by men from the Empire Stone Company's works, near Leicester.

The reinforcement consisted of "Indented" steel bars, ⅓ in. sq., placed 12 in. apart. Every fourth bar was carried through the channels and turned over, at the request of the London County Council. A section of the platform is shown in *Fig.* 3. It will be seen that they are only 2 in. thick, but are amply strong enough. A test of these slabs was made in the presence of the London County Council and other gentlemen interested, before the work was taken in hand, and proved quite satisfactory, although at the time the concrete was practically green.

The chief difficulties in connection with the work were the bad state of the ground and the constant shifting and laying of the pipe-line for the supply of water. It will be noticed from *Fig.* 3 that studs were inserted in the concrete for fixing the timber seats. These studs are embedded 1 in. only, but have proved entirely satisfactory, and have not been wrenched out in tightening the nuts, as might have been thought. The progress made on the platform during the latter stages was approximately 1 mile per week.

The Stadium is capable of accommodating 80,000 to 100,000 people, and is probably unique in this way, as it enables one to see at a glance no less than one-tenth of a million persons. At the ends of the Stadium the accommodation consists of double rows of steps making seventy-two tiers from top to bottom, but this is for standing room only, no seats having been provided.

The whole of the works are to the instructions of the Commissioner-General of the Franco-British Exhibition.

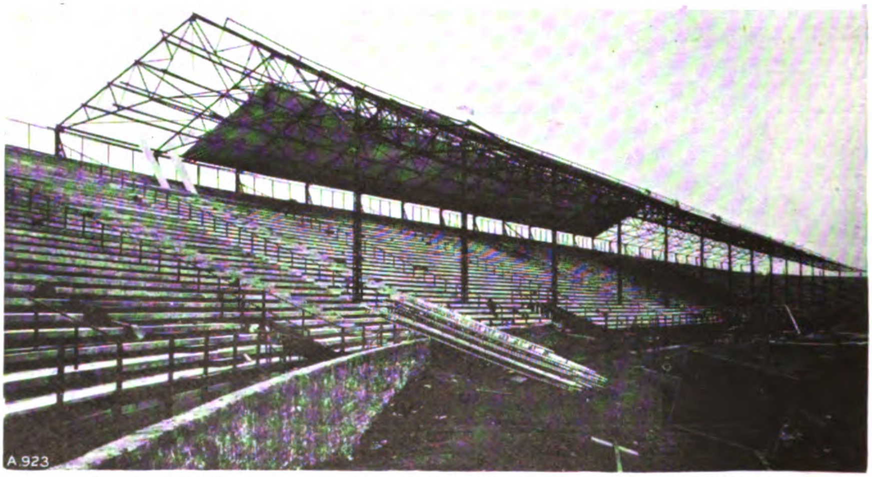
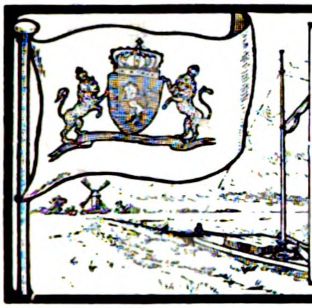


FIG. 6. THE REINFORCED CONCRETE STADIUM AT THE FRANCO-BRITISH EXHIBITION.
(Roofing in course of construction.)



REINFORCED CONCRETE SEA DEFENCES. III.

DUTCH EXAMPLES.

Concluded.

By H. HUISMAN, C.E., Zierikzee, Holland.

(Translated from the Dutch)

At a period when the question of coast erosion is occupying general attention, the article presented herewith, from the pen of Mr. H. Huisman, should be an interesting contribution on the subject of groynes for sea defence works, indicating as it does the great practical use and economy of reinforced concrete in this class of structure.—ED.

IN the two previous articles of this series, the De Muralt system of constructing dyke-walls and protecting the slopes of dykes and sand-dunes with reinforced concrete was described and illustrated, and in this concluding article the construction of a groyne on the De Muralt system, as executed on the northern coast of the Island of Schouwen, Province of Zeeland, Netherlands, will be dealt with. This is one of the first reinforced concrete groynes to be erected.

In connection with the construction of foreshore protection or groynes, the working periods are extremely limited owing to the short interval of time between two consecutive tides. Hence it is that the above-mentioned groyne has been constructed of slabs and framing beams on the lines of the slope-facing dealt with in the second article of this series—in the March issue of CONCRETE AND CONSTRUCTIONAL ENGINEER-

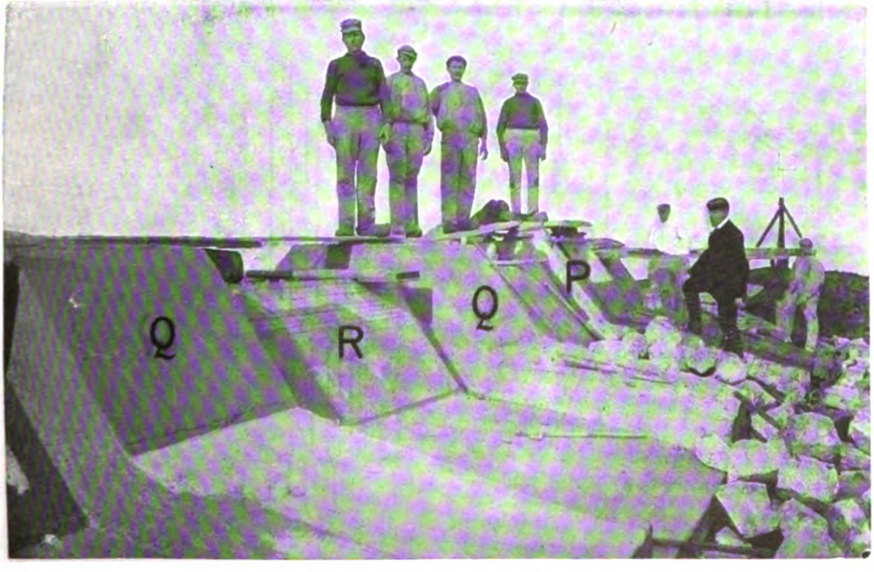
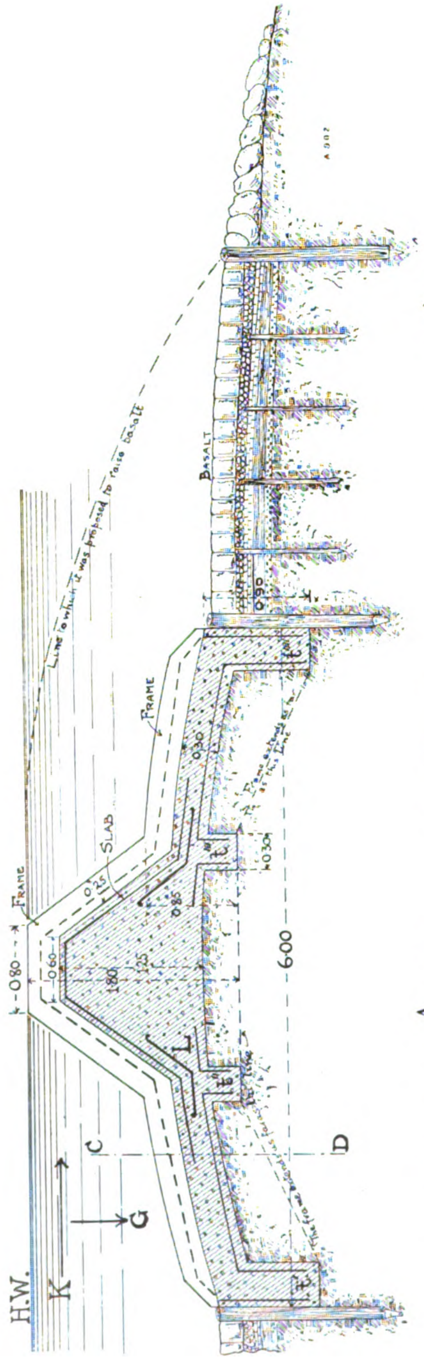


FIG. 2. REINFORCED CONCRETE GROYNE COVERING.


H.W.
K
G
C
D
L
Frame
0·80
0·60
0·25
Slab
1·80
1·25
0·85
6·00
0·30
Frame
0·30
Basalt
0·90
Line to which it was proposed to raise basalt
Frame extends to this line
The frame extends to this line
A 907

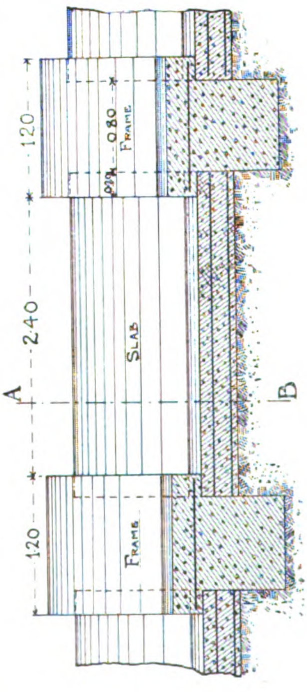

120
2·40
120
A
B
Frame
Slab
Frame
0·80
0·20

Fig. 1.

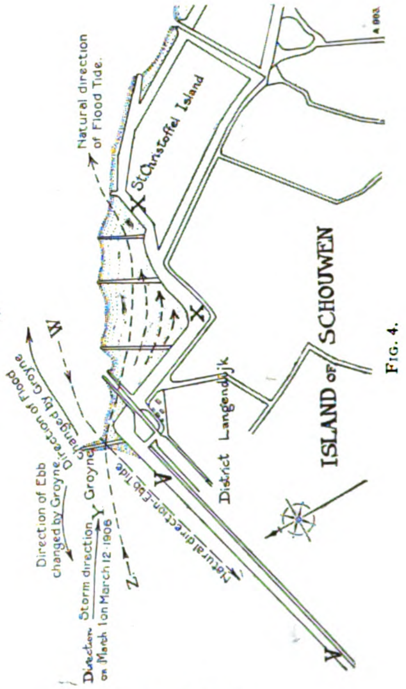

Natural direction of Flood Tide.
St Christoffel Island
ISLAND OF SCHOUWEN
District Langendijk
W
X
X
Y
Z
V
V
Direction of Flood changed by Groyne
Direction of Ebb changed by Groyne
Direction Storm direction on March 1 on March 12 1906
Groyne
Natural direction Ebb Tide
A 903

Fig. 4.

ING. *Fig.* 2 shows the form of construction adopted, R being the slab and Q Q the framing. Either one slab or one frame is constructed between every two tides, the slabs and frames weighing 12,000 kgs. and over.

This method of construction was first applied to an existing basalt groyne. We shall here record full details of the construction and the reasons which led to the groyne being raised. Sea defences of reinforced concrete are cheaper than those constructed of any other material, and they afford better protection against storms. The amount of money economised is so great that enquiry into the durability of such reinforced concrete defences seems superfluous, provided they have only the strength of basalt defences. It has been proved that the reinforced concrete facings for the defence of dunes are so much cheaper than basalt facings that the difference in cost capitalised would, if put out at compound interest, yield the capital originally expended in eleven years. Therefore a reinforced concrete dune-facing on the De Muralt system need not last longer than eleven years to show economy. But engineering experts consider the reinforced concrete facing to be superior to a basalt facing, as is clearly proved by the numerous applications of the De Muralt facing in different places.

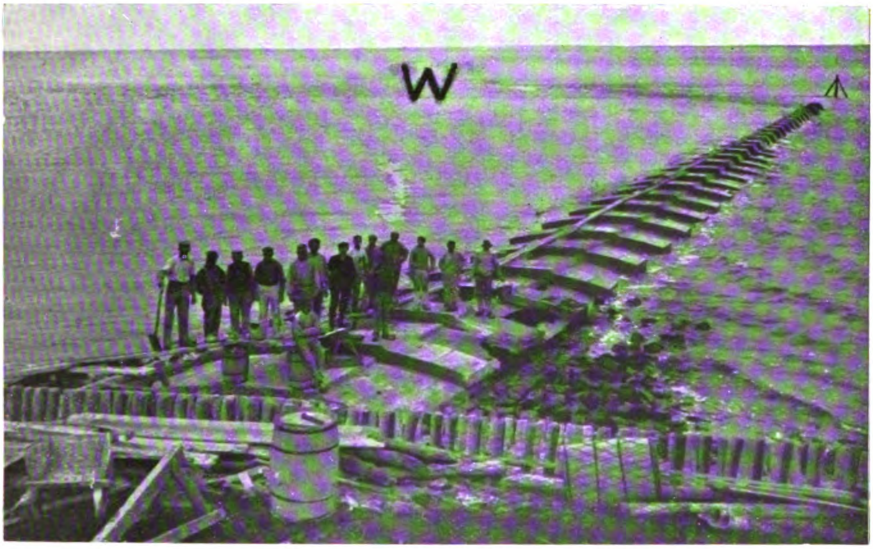


FIG. 3. REINFORCED CONCRETE GROYNE COVERING ON THE ISLE OF SCHOUWEN, HOLLAND.

The above-mentioned groyne—shown in its completed state in *Fig.* 3—on the northern coast of the Island of Schouwen, is subject to heavy assaults by the sea, even when the weather is calm, both from the ebb tide (the direction of which is shown by the arrow marked W in *Fig.* 4) and the flood tide (the direction of which is shown by the arrow marked Z in *Fig.* 4).

When this basalt groyne was constructed, some time ago, it was intended to protect the sea wall marked V-V, but especially the sea wall X-X (see *Fig.* 4). It was soon clearly proved, however, that groynes called upon for such heavy duty, if constructed on the ordinary system with basalt facing, were only able to successfully resist the onslaughts of the sea if their bases were broad. In this case the idea of broadening the base was dismissed, as the cost would have been too great, and in order to avoid damage by storms it was decided to lower the groyne. The result of reducing its height was the frequent damaging of the section of wall X-X (*Fig.* 4), the damage being very serious even when the storms were moderate.

During the gale of March 12th, 1906, when the tidal wave (the direction of which is marked Z in *Fig.* 4) joined with the direction of the storm (shown by Y in *Fig.* 4), the water was thrown over the top of the sea wall, notwithstanding its level being 5 m. above high-water mark. This part of the wall moved and slid backwards, almost rupturing the dyke, which catastrophe, had it happened, would have meant great loss of money and of life. Immediately after this accident it was decided to raise the groyne another 1·5 m. in height, and to execute this defence work in basalt, the profile of which is indicated by the dotted line in *Fig.* 1. The cost of this work was estimated at 21,000 guilders. When it was shown that the work could be done cheaper and better on the De Muralt system of reinforced concrete construction the basalt project was abandoned. The groyne, heightened and altered in reinforced concrete, according to the scheme finally adopted, has already resisted many storms and has proved itself able to repulse ebb and flood tide far from the sea wall and to protect the portion X-X (*Fig.* 4) against damage. The cost of the construction has amounted to only 10,000 guilders, while the materials are of the best quality and there is no question of the sea breaking up this sea defence. The foot of the seaward end, as far as the end itself, is protected on either side by layers of osiers and broken stone, but as this work was already executed some time before, its cost has not been included in that stated for the new reinforced concrete construction.

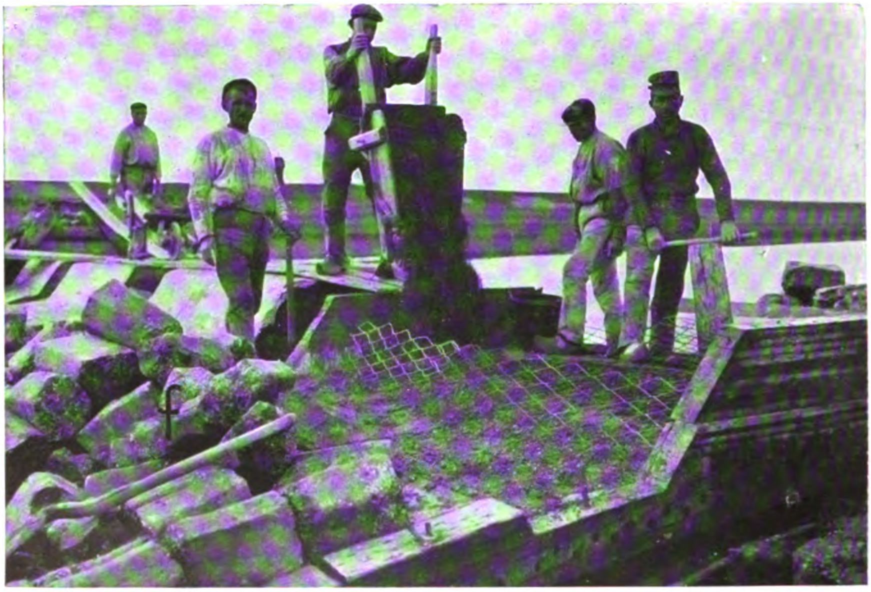


FIG. 5. CONSTRUCTING A SLAB.

The work was executed in the following way: Between each ebb and flood tide a slab was constructed, a length of about 45 cm. of the existing basalt layer being removed for the purpose. The form for constructing these slabs is shown in *Fig.* 5. Every slab is provided with a raised back, the height of which is successively increased, each slab having a higher back than that immediately preceding it. The heightening of the back was accomplished by raising the sides of the form at the head each time by means of one board on the flat, the building up of these sides in layers being clearly visible in *Fig.* 5. The thickness of these boards was determined by dividing the difference in height between the shore end and the seaward end of the groyne by the number of slabs to be constructed. The vertical covering boards were likewise gradually built up in small pieces. In this way all the slabs could be constructed with the aid of the same form, which was easily used for determining the height of the groyne. The slabs with their reinforced concrete sides reach far enough over to obviate any danger of the substratum being carried away; the middle portion of the slabs is moreover provided with reinforced concrete teeth, marked t′, t″, t‴ and t⁗ in *Fig.* 1, which view gives full particulars of their construction and reinforcement.

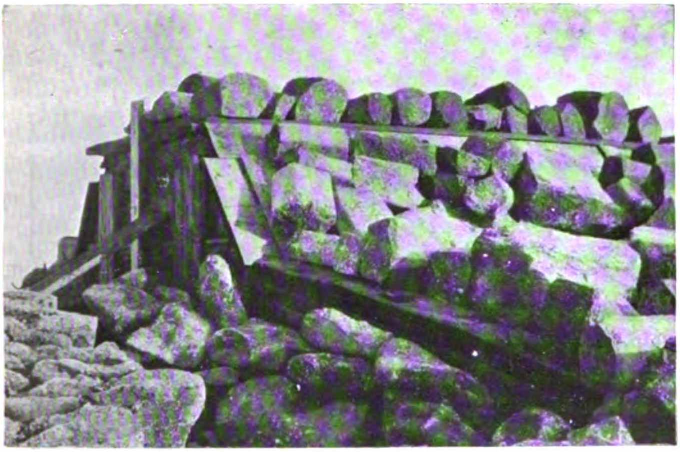


FIG. 6. THE WOODEN FORM FOR SLABS, WEIGHTED DOWN BY BLOCKS OF STONE.

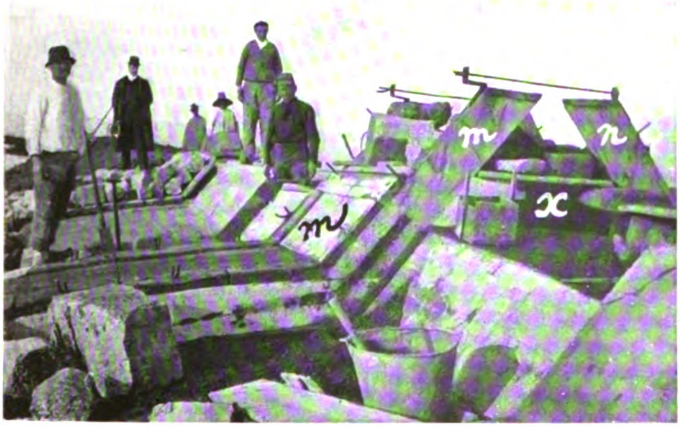


FIG. 7. WOODEN FORM FOR CONSTRUCTING REINFORCED CONCRETE FRAMES TO SLABS.

A large quantity of concrete needs to be made by means of the concrete mixers three quarters of an hour before the placing of the wooden form, the available time left between the ebb and flood being utilised for the building up of the form and the bringing of the concrete, this work requiring twenty labourers. The underside of the wooden form, as well as all its joints, were carefully stopped with greasy clay obtained from the shoals, and to prevent it being raised by the flood tide, heavy stones were loaded upon the top, as shown by *Fig.* 6, and strong chains fastened the form to anchors. A heavy storm twice caused the frame and its contents to be washed away and broken up, but the total damage only amounted to a few hundred guilders.

After twenty-four hours the form could be raised, when all the parts of the slab were highly finished and sufficiently hardened.

The reinforced concrete frames are heavier than the slabs themselves, which they overlap for 20 cm. length and to a thickness of 25 cm. They reach on either side of the slabs as far as the outer slab-teeth (*Fig.* 1). The construction of these frames and wooden form-work is clearly shown in *Figs.* 2 and 7.

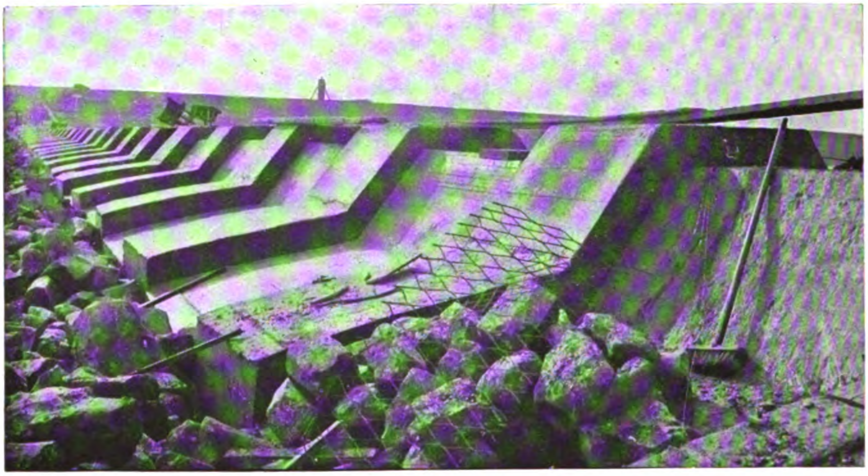


Fig. 8. View of Groyne from Seaward End.

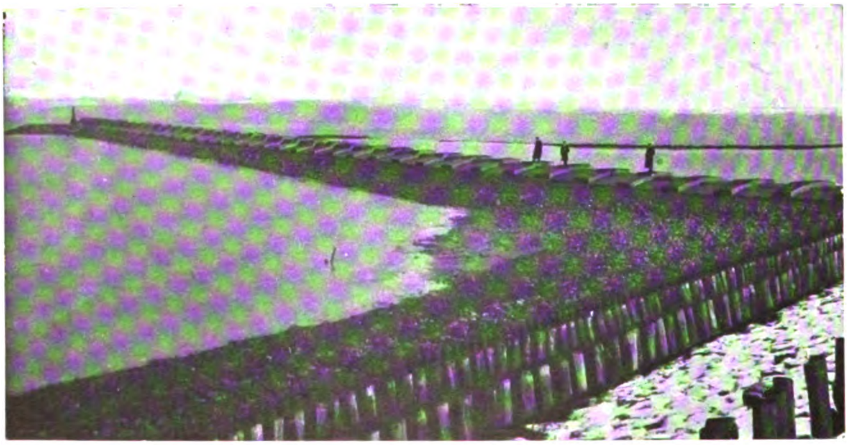


Fig. 9. Side View of Groyne from Sea Wall.

The particular form of the slab with a raised back is not only the result of saving material, but has a theoretical purpose, for the groyne is called upon to resist numerous external forces that try to break it up. The momentum of the mass of moving water (*k* in *Fig.* 1) tends to push over the raised back, but this very same mass of water, by reason of its weight G, will hold down the slab, provided the reinforcing of the kneeparts L is strong enough. The regular reinforcement of Expanded Metal requires reinforcing in each knee-part L by means of six iron bars of sufficient diameter.

One slab cannot be carried away or moved from its place, for to do so would require the whole of the groyne to be disentangled and the teeth t (*Fig.* 1) entirely ruptured. Slight curling waves, which do not give rise to the agent G (namely, weight of water on slab), will not cause great damage . It is chiefly due to the system of making such slabs and frames independent from one another that such reinforced concrete sea defences are able to resist the onslaughts of the sea, which have proved so disastrous to monolithic reinforced concrete sea defences by reason of their being wanting in elasticity.

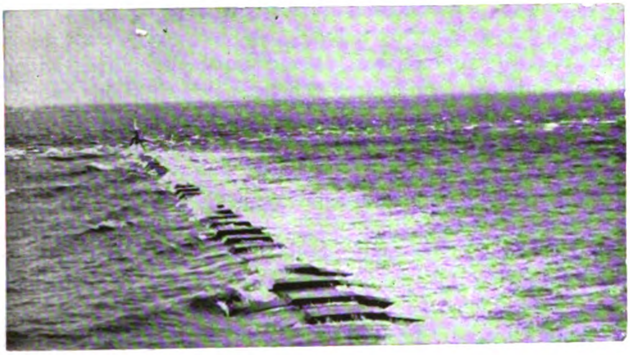


Fig. 11. View Showing Groyne Breaking Surface Water.

A groyne is chiefly intended to utterly change the current of the stream which it is desired to keep off the shore. *Fig.* 3 shows clearly how the ebbing water is thrown back in a direction at right angles to its previous direction. The higher the groyne is raised the better will it perform its work, the efficiency of any groyne depending upon its height. Every groyne, even the so-called blind dams, invisible at low tide, has a practical influence on the position and the division of the current axis. As long as there is a dam of any height there will be an effect. If the requisite height can be obtained most easily and cheaply by the use of reinforced concrete it is bound to be preferred, as that is all that is needed; this is mainly the case where existing groynes require to be raised or have their facings replaced by a material of greater resistance to the onslaught of the sea.

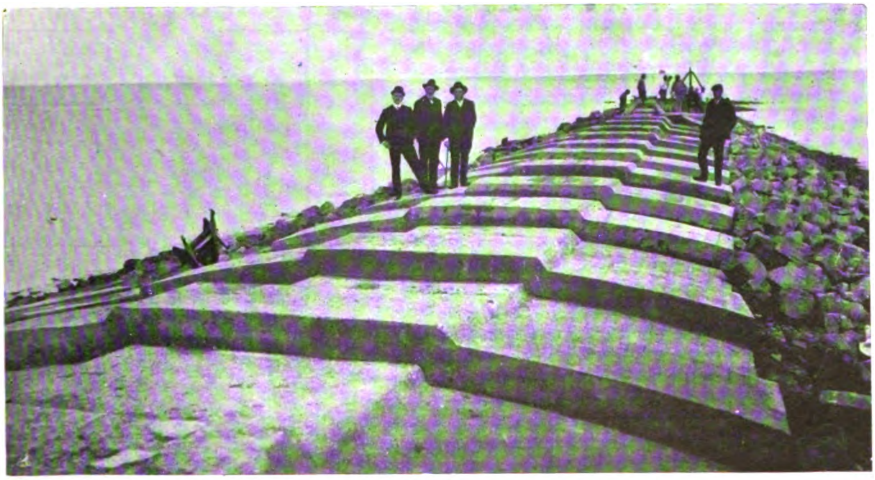


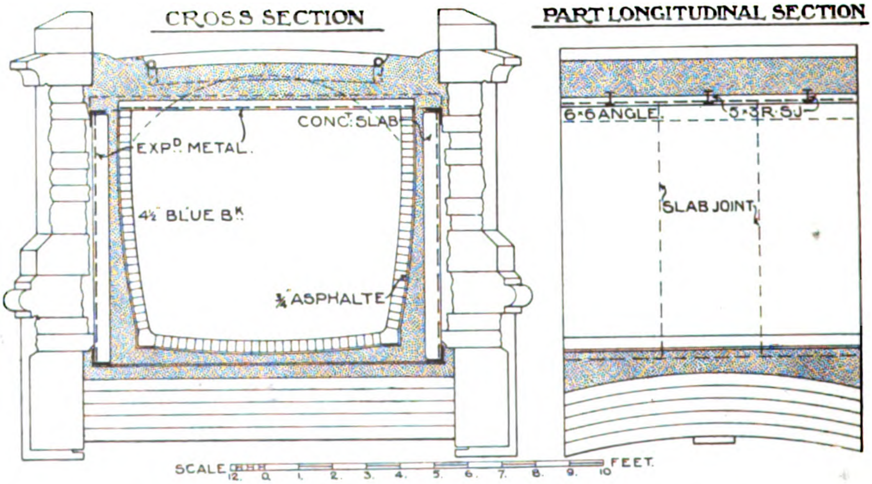
Fig. 10. View of Groyne from Sea Wall.

Where no new groynes are needed, nor need be constructed, the above described method can be entirely followed for that part of the foreshore from which the water completely retires at low tide. It has been proved also that a good plan to be followed in constructing a new groyne by sinking heavy blocks, is to protect the top by a basalt covering that can be replaced by a reinforced concrete one a few years later. The great saving in cost effected by the use of reinforced concrete in the construction of new groynes completely justifies the adoption of that material if circumstances permit.

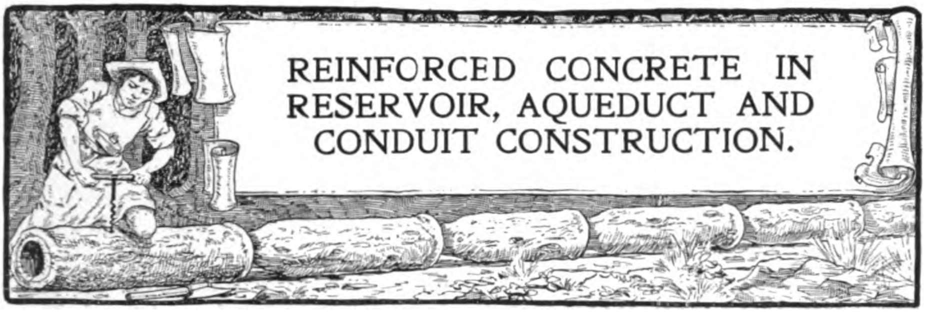
Fig. 8 is a view of the groyne from the seaward end. *Fig.* 9 shows it sideways from the adjoining sea wall. *Fig.* 10 is a full view from the sea wall looking directly towards the sea end. *Fig.* 11 shows how the groyne breaks the surface water.

It should be borne in mind that the function of a sea dam or pier differs widely from that of a groyne; yet both kinds of sea defences can be successfuly constructed on the De Muralt principle. In the case of a sea dam or pier there are always more parts at right angles to the beach, and they serve to move the direction of the current parallel to itself without changing this direction in any way. The efficiency of such dams or piers depends, therefore, upon their length and not upon their height. A dam of next to no height will prove to be at a level with the normal beach, and is sometimes for this reason cut in the beach. Its top always takes the incline of the beach; its sea end should be defended by sinking heavy rock and broken stone, and well protected against erosions.

Dams of any considerable height are only needed to keep back the sand, to resist the attacks of storms, but not those of tidal waves, and careful attention should be paid to the kind of storm in order to settle the direction of a dam. Since no particular attention need be paid to the height of dams, their defence by reinforced concrete slabs and framework entirely constructed on the De Muralt principle is to be highly recommended. Dams have been partially protected on the Island of Schouwen, as well as at other places, so as to give the De Muralt system a fair trial. Disregarding the clay covering, a dam on the Island of Schouwen has cost 6 guilders per sq. m.



DETAILS OF AQUEDUCT ABOVE GROUND FOR THE BIRMINGHAM CORPORATION
(*See page* 129)



REINFORCED CONCRETE IN RESERVOIR, AQUEDUCT AND CONDUIT CONSTRUCTION.

PART II.—CONDUITS, ETC.

By E. R. MATTHEWS, A.M.Inst.C.E., F.R.S.E., F.G.S.,
Borough Engineer, Bridlington.

In our issue of November last, Vol. II., No. 5, we dealt with some examples of reinforced concrete reservoir construction, the author being the Borough Engineer of Bridlington, Mr. E. R. Matthews, F.R.S.Ed.

We are now presenting two further comprehensive articles on the subject of reservoirs and conduits by the same author, the second of which appears below.

There can be no doubt that the application of reinforced concrete for waterworks engineering, i.e., for reservoirs, water towers, tanks, conduits, and large pipes, has been found economical, and we should refer to some of our previous articles and notes as to the manner in which the material has been applied both at home and abroad.

One of our articles, which appeared in Vol. I., No. 3, Reinforced Concrete Water Mains, by Mr. R. H. Wyrill, Water Works Engineer of Swansea, we think merits special attention.—ED.

REINFORCED CONCRETE IN AQUEDUCT AND CONDUIT CONSTRUCTION.

(a) The suitability of this material.—That reinforced concrete is eminently suitable for use in the construction of aqueducts and conduits is a certainty. Most of the advantages claimed for this material in connection with reservoir construction are also applicable to its use for aqueducts and conduits. The two greatest advantages of this material for this purpose being, in the author's opinion: (1) Its great hygienic value (it is easily cleansed and does not harbour microbes); and (2) it increases in strength with age.

In a paper by the author, entitled "Reinforced Concrete Sewers and Conduits in the United States of America," which appeared recently among the "selected" papers in the Transactions of the Institution of Civil Engineers, the author dealt fully with this subject, and gave a large number of American examples of sewers and conduits built of this material. He also pointed out that the time was rapidly approaching when this material would be generally adopted in America for sewer and conduit construction.

(b) Typical examples.—It is his intention now to describe briefly one of the most important reinforced concrete conduits in America, and three of the most modern British examples.

(1) AMERICAN EXAMPLE.

Waterworks Conduit, Jersey City, N.J., U.S.A.—This is undoubtedly the most notable reinforced conduit in the United States. It is 8 ft. 5 in. in diameter, and was built in 1903 in connection with the water supply of Jersey City. The conduit is nearly four miles long. The sections varied according to the cutting, whether in rock, earth, etc.

The reinforcement consisted of twisted square steel bars, circumferential bars, ⅜ in. square, spaced 12 in. apart, and longitudinal bars, ¼ in. square, spaced 2 ft. apart. The concrete used was composed of one part Portland cement, two parts sand and five parts broken stone, 1½ in maximum size

Method of Construction.—The centres for this conduit were made in 12·5 ft. sections, each section consisting of eleven segments, which weighed about 200 lbs. each. The invert was formed by screeding, it being finished by troweling while the concrete was plastic. The centres were left in place about 24 hours before removal, and sometimes they were greased with vaseline to facilitate their removal. Planking, 12·5 ft. in length, was fixed to shape the exterior of the conduit; this was carried up as the work proceeded.

At the end of each day's work a groove was formed in the concrete to facilitate the bonding in of the next day's work. Practically no finishing was required on the inside of the conduit.

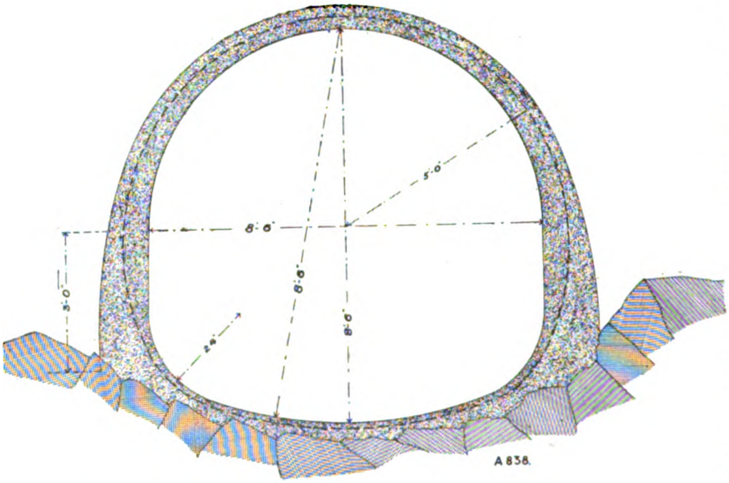
As an indication of the speed with which this work was executed, the author would name that 2,586 ft. of conduit were constructed in 65 days by a gang of 38 men, or an average of about 40 ft. per day.

BRITISH · EXAMPLES.

(a) Conduit for the West Hartlepool Corporation.—This culvert, known as "Carr House Culvert," was constructed over a watercourse (nearly 9 ft. in width), discharging on to the foreshore, and is about 127 yds. in length, the material used being expanded steel (with 6 in. overlap joints), embedded in clinker concrete.

The clinker used was obtained from the Corporation refuse destructor works, was broken and screened ($\frac{1}{4}$ in. to $1\frac{1}{2}$ in. gauge), and mixed in the proportion of five parts to one of sand and one of cement.

The cement was of English manufacture, having a tensile resistance of 475 lbs. per sq. in., after 21 days, when formed into briquettes.



WATERWORKS CONDUIT, JERSEY CITY, N.J., U.S.A.

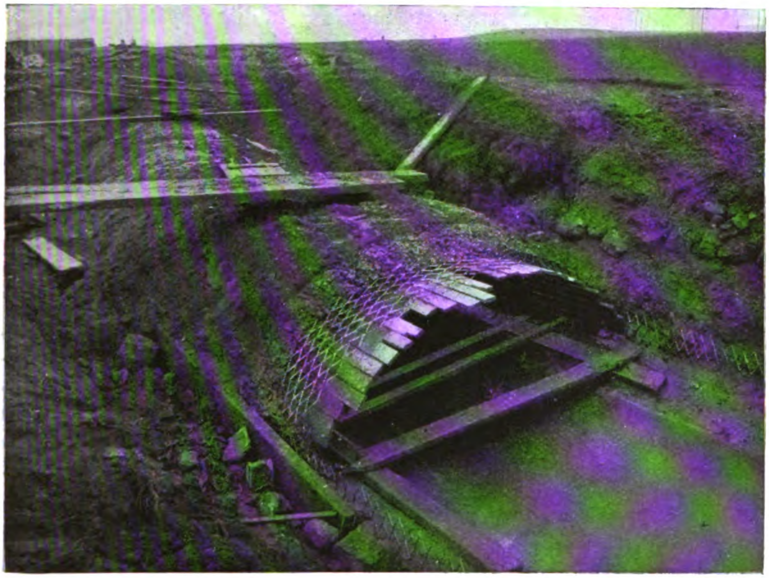
The steel reinforcement was Expanded Metal (No. 10 section, 3 in. mesh, $\frac{1}{4}$ in. by $\frac{3}{4}$ in.), and was sandwiched between layers of concrete, as will be observed from the drawings and photographs.

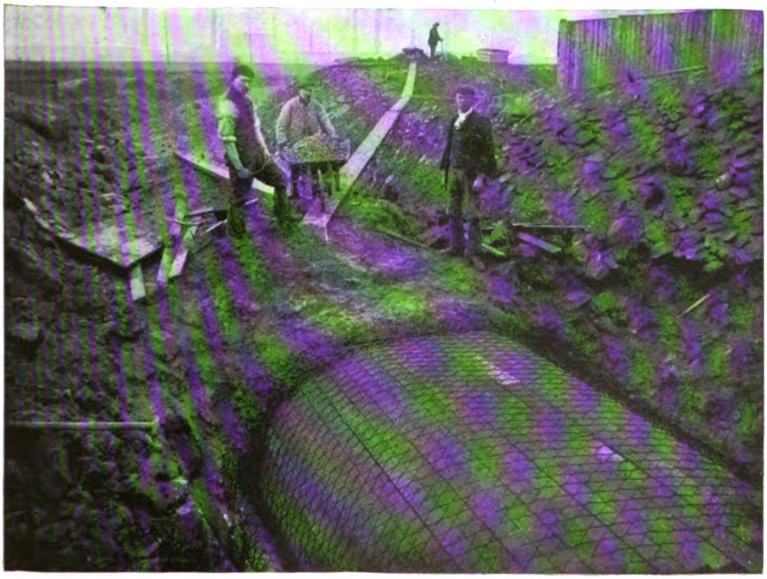
The whole of the invert surface, and for 2 ft. up each side of the culvert, was rendered in cement and sand to a smooth surface. The depth from invert to underside of crown is 3 ft. 11 in. The work was completed nearly three years ago, and is in excellent condition, as one would naturally expect to find it; and the cost, exclusive of filling in, but inclusive of two manholes, was £305. This represents something like 46s. 6d. per yard run for the reinforced work.

This culvert was designed by Mr. Nelson F. Dennis, A.M.Inst.C.E., the borough engineer of West Hartlepool.

(b) ***Loch Leven Conduit.***—This is an interesting conduit, recently built for the British Aluminium Company, in connection with their Loch Leven water power, at Kinlochleven, situated on the borders of Inverness-shire and Argyllshire.

It is 8 ft. by 8 ft. inside measurements, and is built entirely of 3 in. mesh expanded steel and concrete *in situ*, slabs of similar material 4 in. thick, being used for the roof. The walls are 9 in. thick at bottom and 6 in. at top, with the reinforcement placed near their outer face. One and a half inch tie rods are placed at intervals under the cover to take up the stress when the roofing slabs are removed. The aqueduct runs along the hill-side for a distance of about 3½ miles, following the natural contour of the ground. A depth of water of 7 ft. 6 in. is allowed for in the conduit. The invert is 6 in. in thickness, the surface of same being formed of 3 in. granolithic, ***in situ.***

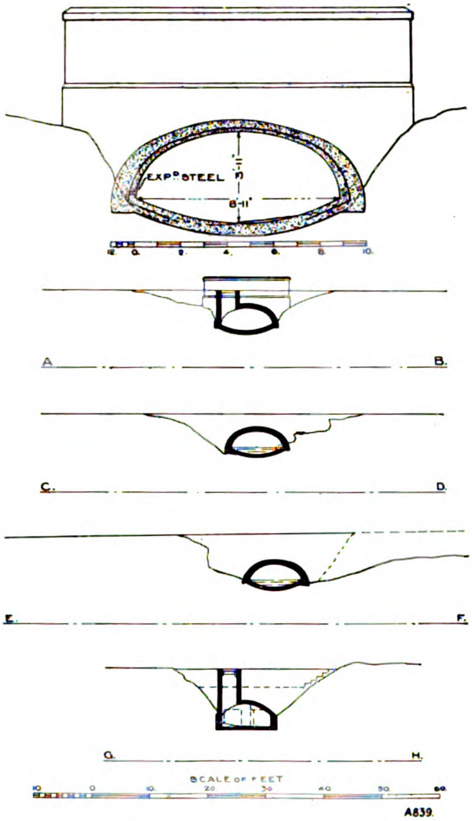




"Carr House" Culvert for the West Hartlepool Corporation.

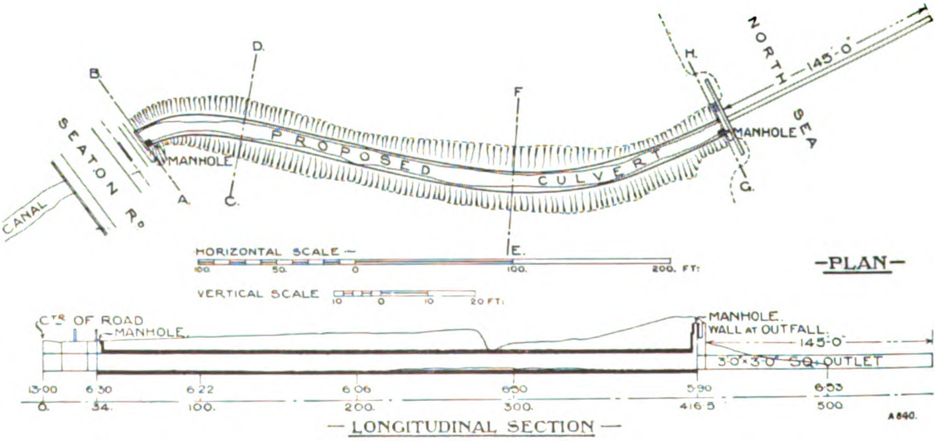
This interesting construction was designed by Messrs. Meik and Sons, of London, the work being executed by the New Expanded Metal Company, Ltd.

(c) Birmingham Corporation Water Supply: Aqueduct above ground.—This aqueduct is 7 ft. high by 8 ft. wide, inside measurements, the inner face of the side walls curving slightly inwards towards the bottom. It is carried on arches, and the conduit is formed by means of a steel framework on a concrete bed, the framework, consisting of 6 in. by 6 in. longitudinal steel angles at the four corners, connected by 3 in. by ½ in. flat bars in the floor and 5 in. by 3 in. rolled steel joists in the roof, the walls being formed of concrete slabs 6 in. thick, reinforced with 3 in. mesh expanded steel with a hearting of concrete, placed *in situ*, coated with asphalte and a 4½ in. blue brick lining as finish. The roof is of concrete slabs, 3 in. thick, reinforced with 3 in. mesh expanded steel, covered with concrete and soiling. The aqueduct is faced with a masonry wall on both sides, an air space being left between the masonry and the conduit proper, and was designed by Messrs. James Mansergh & Sons, of London.



CONCLUSION.

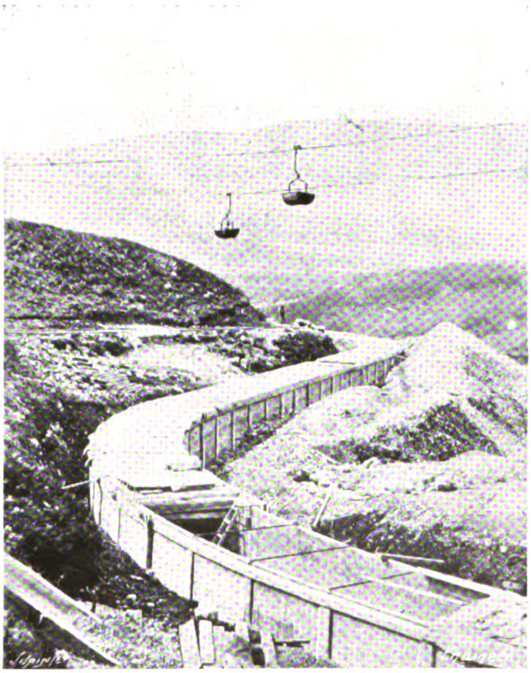
The author has endeavoured to show that there is a growing tendency in this country, as on the Continent and in



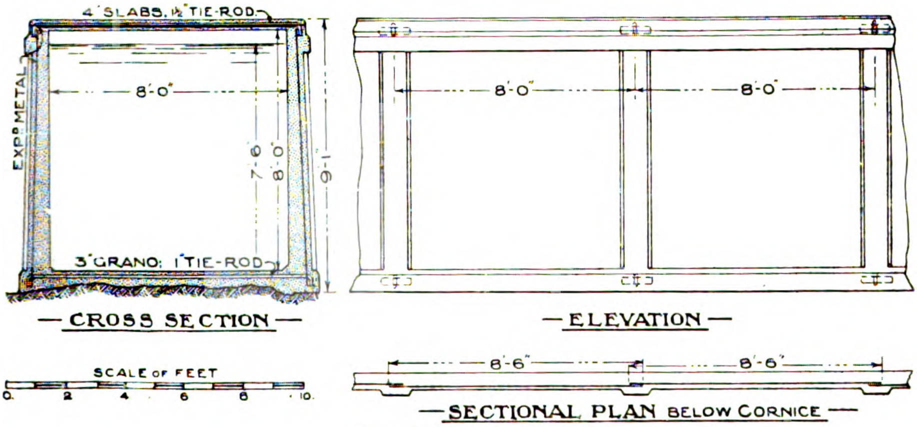
Culvert for the West Hartlepool Corporation known as "Carr House" Culvert.

America, to use reinforced concrete in reservoir, aqueduct, and conduit construction. He has also shown that there is a saving in cost by adopting this material, and has pointed out that, in his opinion, this is the material that will be generally adopted for works of this class in the not very distant future.

The author wishes to express his indebtedness to Mr. A. W. Buel, the writer of that interesting American work, published by *Engineering News,* entitled "Reinforced Concrete," for particulars respecting reinforced concrete reservoirs and conduits in the United States; to Messrs. Thos. Meik and Sons, for drawings and valuable particulars as to the Loch Leven conduit; to Mr. N. F. Dennis, A.M.Inst.C.E., the borough engineer of West Hartlepool, for drawings of and interesting notes on the "Carr House" culvert; to Messrs. J. Mansergh and Sons, for the particulars of the aqueduct built in connection with the Birmingham Corporation Water Supply; to the editor of the *Engineer,* for some useful information; and to the New Expanded Metal Company, for some of the photographs illustrating this contribution.



Conduit for the British Aluminium Co., at Loch Leven, Scotland.



Loch Leven Conduit.

NOTES ON THE USE OF CONCRETE IN MINES

II.

Of the many instances in which the use of concrete and reinforced concrete has been neglected in this country, none are more remarkable than those connected with mining.

There are innumerable uses for concrete and reinforced concrete in mines. Timber is getting more and more expensive, deteriorates very rapidly in some mines, requires constant repair and reinstatement, and is dangerous to a degree in mines where there is a fire hazard.

In our previous issue we called attention to examples where concrete and reinforced concrete had been used in mines in the United States, in a contribution from the pen of Professor W. R. Crane, of the Columbia University of New York.

In the following pages we summarise the mining section of the excellent Handbook on Reinforced Concrete, edited by Dr. Fritz von Emperger of Vienna, and published last year by Messrs. W. Ernst & Son of Berlin.

The importance of reinforced concrete in mines, according to the view of the Editor of the Handbook, may be gauged from the fact that he has given his collaborator, Mr. B. Nast of Frankfort, space to the extent of over 20 quarto pages to deal with the subject, and all interested in the question of using concrete in mines would do well to obtain the handbook, if only on account of this particular chapter.

Both the data we present and the illustrations are taken from the book in question, and together with the previous article referred to above a review may now be said to have been presented by us of some of the principal uses of concrete and reinforced concrete in mines.—ED.

ALTHOUGH the special characteristics of reinforced concrete render it capable of great utility in mining practice, it is only quite recently that it has found any great application in this direction. So far back as 1891 attention was called to its advantages in the German mining engineering press, and even in 1887 one of the mines near Goslar had been equipped with reinforced concrete drainage system, but practically all the useful examples of this form of construction belong to the last few years.

For works above ground, such as the head works of the shafts, pumping stations, buildings for concentrating machinery, etc., reinforced concrete is, of course, eminently suitable, especially when the treacherous nature of the ground in the immediate neighbourhood of mines is considered, but the design and construction of such works above ground will not differ in any essential respect from those of ordinary buildings, and they need not be considered at present.

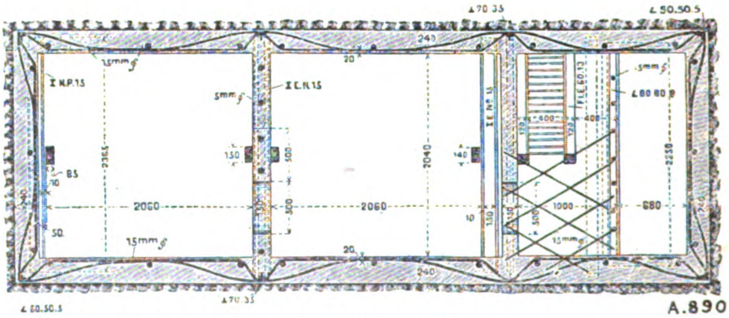


FIG. 1. EXAMPLE FROM THE WILHELM SHAFT OF THE KONIG COAL MINE, NEUNKIRCHEN.

For underground purposes, the lining of shafts and galleries and the construction of ventilating partitions offer the principal occasions for the use of reinforced concrete, but some minor uses, such as the construction of underground stores for explosives, and of tracks or guides for railways or cages, have also been found.

Concrete alone has been used repeatedly in German mines for lining shafts, a staging being erected, carrying the wooden centring, behind which the concrete is filled and rammed. As each ring is completed, the staging and its centring are raised and another ring proceeded with. When the shaft is being sunk through very wet strata, cement has been found to be advantageous, a liquid cement being forced in under pressure through bore-holes. When this method was employed in a coal mine at Lens, in Northern France, the cost was found to be not greater than that of freezing the strata, and the execution was much less difficult. Segmental concrete blocks have also been used in place of iron tubbing for lining a shaft at the Roland Mine, Oberhausen.

A good example of a reinforced concrete shaft lining is afforded by the Wilhelm shaft at the König coal mine, Neunkirchen. The wooden lining having decayed, was replaced by concrete with steel reinforcement, the design of which will be seen from *Fig.* 1. The work proceeded from below at the rate of 1·5 m. daily, the cost amounting to £8 10s. per metre, or less than that of a brick lining. The reinforcement consisted of round iron rods, 15 mm. dia., placed horizontally at distances of 100 mm., and of twenty-four equally spaced vertical rods. At each corner, angle irons 70 by 35 mm. were fixed. Pipes were inserted at intervals to drain away water as it accumulated behind the concrete. Wooden shuttering was used, but the experience of the engineers concerned led them to the opinion that iron is preferable in such cases.

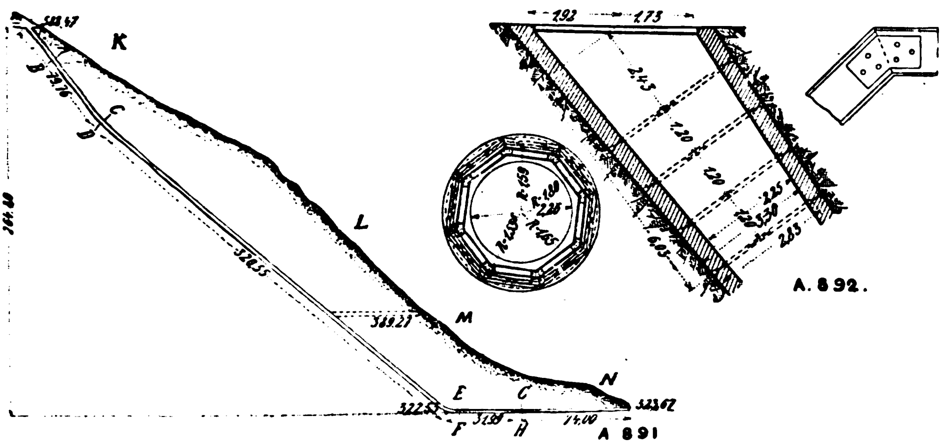
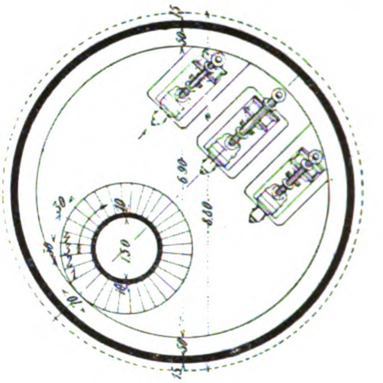


FIG. 2. REINFORCED CONCRETE CANAL AT LOS ANGELES.
K = Emergency Duct. L = Ground Surface.
M = Emergency Duct. N = Mouth of Shaft.

FIG. 3.
ARRANGEMENT OF
REINFORCEMENT.

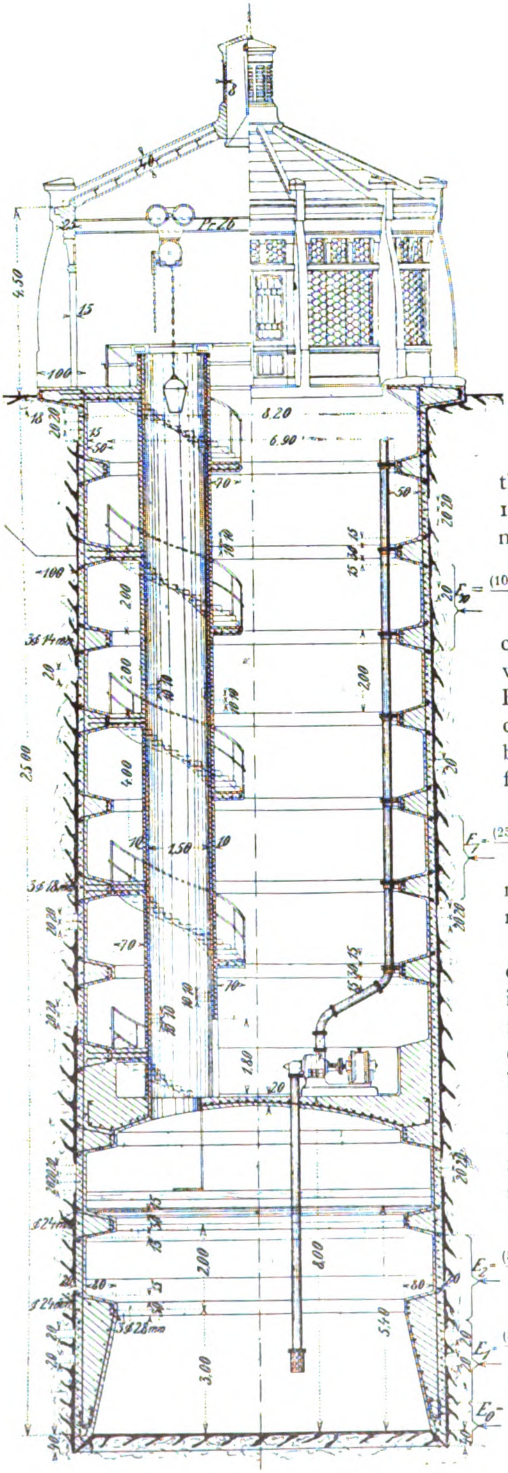
In another German coal mine, the Glückhilfs-Friedenshoffnung mine at Hermsdorf, it was necessary to construct a large ventilating shaft in strata subject to the influx of water. This shaft is 4·7 m. dia., and consists of a concrete wall 30 cm.



thick, reinforced with vertical rods 10 mm. dia., and with a wide meshed network of lighter wire. The strata being wet, sacks were used for keeping back water during the filling of the concrete, except in the wettest places, where iron drainage tubes were built in. For finishing and waterproofing the concrete wall the hardened surface was brushed with a wire brush, and then two finishing layers of mortar applied, the first being 8 to 10 mm. thick; the final coat, 5 to 8 mm. thick, being mixed with warm soda solution and rapidly applied to ensure quick setting.

A very similar ventilating shaft, 4 m. dia., was constructed at the Reden mine in the Saar district. Here, also, vertical reinforcing rods and iron netting were employed, the thickness of the concrete being only 15 cm.

The number of shafts constructed in this way is even now very small, if only mines are considered. But in the construction of wells, ventilating shafts for tunnels, water-power canals, etc., conditions occur which are very similar to those in mines, and the experience derived from the one class may be with advantage applied to the other. Several such shafts have been described.



4.50
Pr.26
8.20
6.90
2500
-100
200
400
1.50
180
200
800
540
300
$E_{30} = \frac{(1000 + 1500) \cdot 2}{2} = 2500$ kg
$E_1 = \frac{(2500 + 2950) \cdot 2}{2} = 5450$ kg
$E_2 = \frac{(5500 + 5500) \cdot 2}{2} = 11\,000$ kg
$E_1 = \frac{(5500 + 6050) \cdot 2}{2} = 11\,550$ kg
$E_0 = \frac{6300 + 6050}{2} = 6175$ kg

FIG. 4. WELL AND PUMPING SHAFT AT REININGHAUS BREWERY, NEAR GRAZ IN AUSTRIA.

An underground canal for water power, descending obliquely to a vertical depth below the hill-surface of 265 m., was constructed at the Bakersfield Power Station of the Edison Electric Co., near Los Angeles, a wrought iron lining being originally employed. After a serious collapse, a form of reinforced concrete construction was adopted. Octagons of I-iron ware built across the shaft at intervals of 60 cm. and connected by means of round iron rods 16 mm. dia., the whole being filled in with concrete to a thickness of 35 cm. The surface was made smooth with a layer of cement, and the canal has proved to be perfectly watertight in use (see *Figs.* 2 and 3).

The simplest construction for vertical shafts is a concrete lining of circular or oval section, reinforced with equally spaced vertical rods, the transverse reinforcement being rods of lesser diameter, closely spaced in the lower part of the shaft, their distance apart increasing as the top is approached. This construction was employed for a ventilating shaft for a tunnel, 140 m. deep, at Massandra in Russia, and for a pumping shaft at Lecce in Italy.

A much larger shaft is the pumping shaft and well at the Reininghaus Brewery, Graz, which is 8·2 m. dia. and 25 m. deep (*Fig.* 4). This has to take the pumping machinery, and has an inner shaft for ventilating purposes, the well being closed by a reinforced concrete vault which serves as the floor of the machine room.

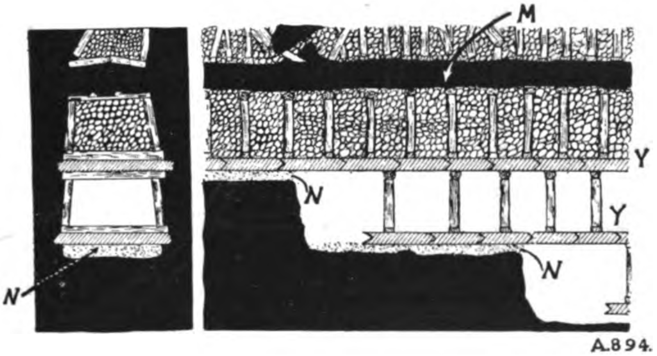


Fig. 5. Use of Reinforced Concrete Slabs in a Coal Mine.
N = Coal Dust. M = Coal. Y = Reinforced Concre:e Sl abs

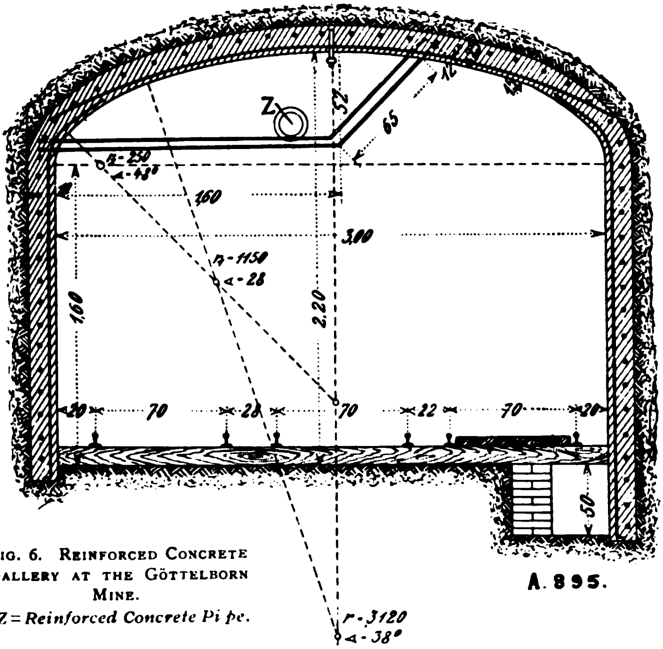


Fig. 6. Reinforced Concrete Gallery at the Göttelborn Mine.
Z = Reinforced Concrete Pi pe.

The construction of concrete stringers for shafts has been described in former issues of Concrete and Constructional Engineering.

For horizontal galleries in mines, concrete is used to replace wood. The usual timbering is very liable to decay, and the collapse of partially decayed props is a

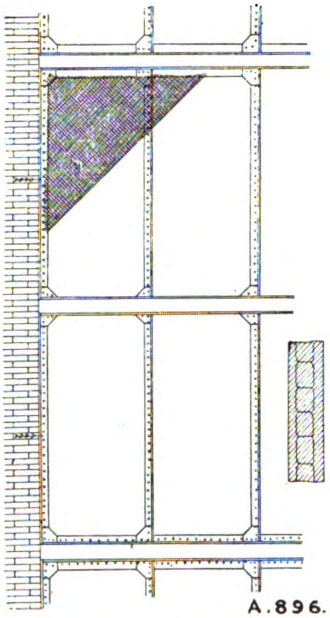


Fig. 7. Reinforced Concrete Ventilation Screen at the Brefeld Shaft at Tarthun.

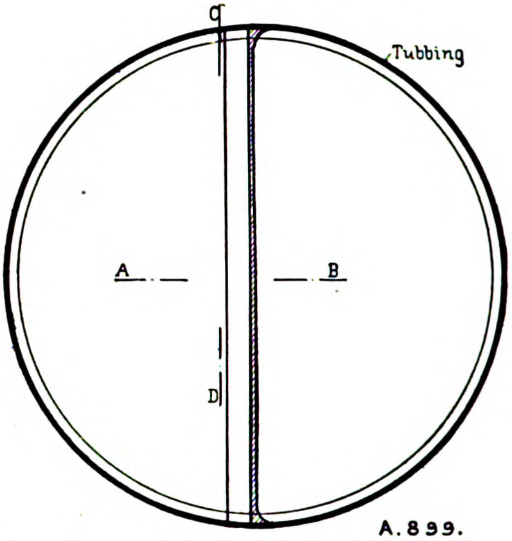
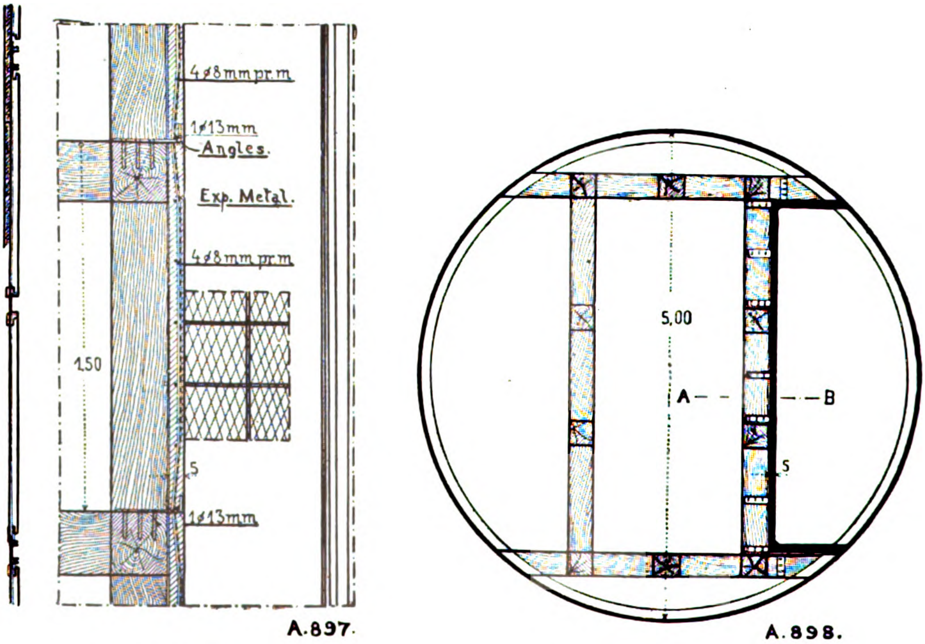


Fig. 8. Reinforced Concrete Ventilation Screen at the Count Schwerin Mine at Castrop.



Figs. 9 & 10. Reinforced Concrete Ventilation Screen at the Nordstern III. Mine.

fruitful source of accidents. Even when collapse does not actually take place, creeping of the floors goes on, and the conveyance of coal or ore along the galleries is rendered difficult or impossible without re-timbering, a costly and troublesome operation. Many different improvements were tested in different parts of the coal mines at Zwickau in Saxony. At first, concrete was rammed behind the timbers to form a backing, but later on old iron rails or I-beams were embedded in the concrete. When as was the case in the mines, both gravel and boiler clinker are available in sufficient quantities for the preparation of the concrete, the cost is not excessive. Most mines have quantities of old rails, etc., which can be used as reinforcement. Some of the galleries thus constructed in the Zwickau mines have been in use since 1890, and have been perfectly satisfactory. The pressures in such galleries are often very great, as will be readily understood from an inspection of the drawings of old timbering and linings which have appeared in the German technical mining press. The advantages of reinforced concrete in such cases are obvious.

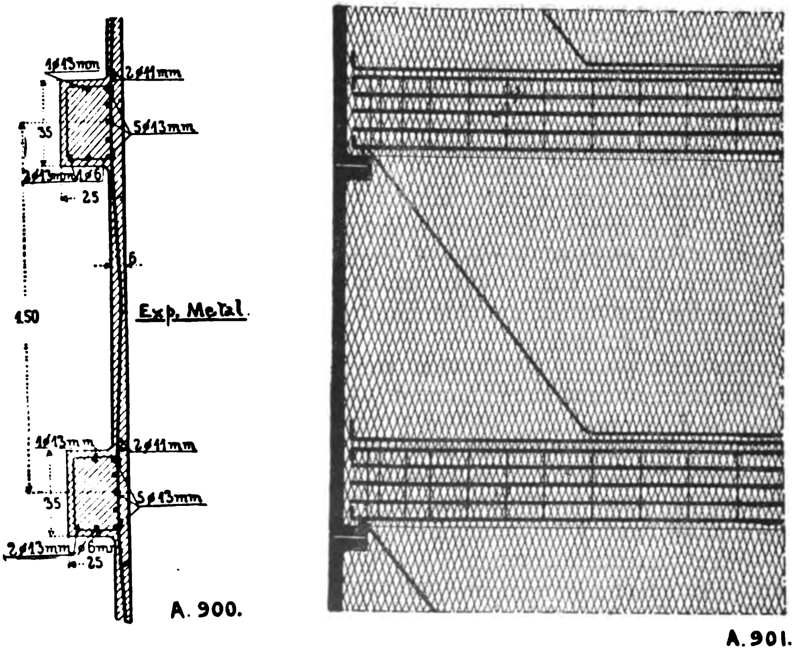
In certain French coal mines it was formerly the custom, on descending from shallow to deeper levels, to fill in the old upper workings in order to lessen the settling of the surface. This necessitates heavy timbering in the lower levels, and also the leaving in of a layer of coal or the construction of a timber floor to support the weight of the rock filling. Both these expedients were replaced by the construction of a concrete floor, the slabs being let into the rock walls of the galleries (see *Fig.* 5). From two to three months were allowed to elapse before the load came upon the concrete in order to give time for hardening. It has been suggested that a further advantage would be gained by the insertion of old rails at intervals.

In several of the German mines, however, much more thorough-going reforms of construction have been adopted. Thus in 1900 a gallery in the Waldenburg mine was constructed with plain concrete walls and an elliptical concrete roof reinforced on the Monier system. Another plan, suitable for galleries of small dimensions, was adopted in a mine at Oberkirchen, the gallery being lined with bricks at the sides, arched roofing slabs, prepared beforehand from concrete reinforced with closely set wires, were set in place. The thickness of the slabs was only 6 cm. at the crown and 10 cm. at the abutments, the span being 1·5 m. This gallery is required to remain in use for thirty years.

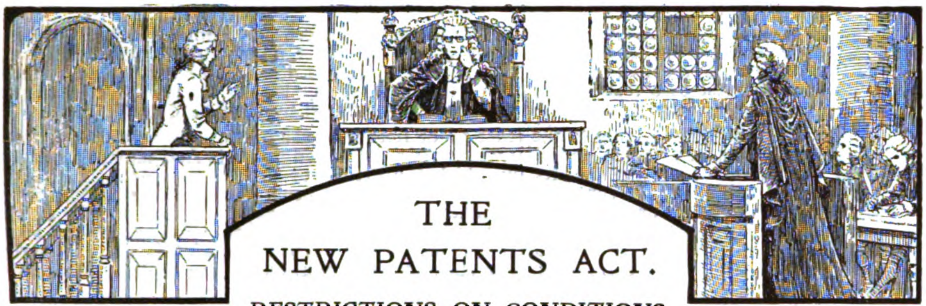
A very good example of a reinforced concrete gallery lining exists at the Göttelborn mine (*Fig.* 6). Sides and roof are here continuous, the thickness of the concrete being only 15 cm., 10 mm. rods being used as transverse reinforcement, and wire longitudinally. As the figure shows, bent old rails are fixed at intervals to carry pipes and electric wires. This lining is stated to have cost only £4 per metre, including labour. The figures given for the cost of such linings are often difficult to compare, as a uniform basis has not been adopted in making the calculations. It must be accepted as a fact that the first cost of the linings is greater than that of brick, and considerably greater than that of timber, but against this must be set the far greater durability, the security against accident, and also the smaller space occupied by the lining, so that less excavation is necessary to obtain a given roadway.

The partitions in ventilating shafts for separating the working from the ventilating shaft, or the upcast from the downcast shaft, are required to be thin, so as not to occupy too much of the valuable space, to have smooth surfaces so as to offer as little friction to air-currents as possible, and to have sufficient stiffness to resist the unavoidable shocks and vibration. This gives reinforced concrete great advantages over brickwork, whilst its superiority to iron plate is evident in its greater durability and less cost. The partitions may be very thin if strengthening ribs are arranged at intervals. The reinforcement is conveniently of iron wire or Expanded Metal, rods being used to reinforce the ribs. The partitions are generally constructed from the top downwards, a suspended stage being used. A very good example is that from the Graf Schwerin mine, at Castrop (*Figs.* 8, 11, and 12). Expanded Metal was used in this case, and the arrangement of the reinforcement and ribs is shown in the *Fig.* In a similar shaft at a mine at Tarthun (*Fig.* 7), the thin reinforced concrete partition is stated to have cost £3 18s. per vertical metre, as against £5 12s. for iron plates.

That the next few years will see a great extension of the use of reinforced concrete in mines cannot be doubted. At present only a few scattered examples of such applications are to be found, but the reports of the mining engineers who have used concrete or reinforced concrete are almost uniformly favourable, and a knowledge of the advantages to be gained is sure to become more widely extended.



Figs. 11 & 12 Reinforced Concrete Ventilation Screen at the Count Schwerin Mine at Castrop.



THE NEW PATENTS ACT.

RESTRICTIONS ON CONDITIONS.

By DOUGLAS LEECHMAN, A.Inst.M.E., Associate of the Chartered Institute of Patent Agents, Barrister-at-Law.

The New Patents Act should be of considerable importance to a number of our readers interested in reinforced concrete, both those specifying the work in their professional capacity, and those executing the work either as specialists or as licensees for specialist systems. It also has considerable bearing upon the use of reinforcement bars, and those who make or use machinery such as concrete mixers and the like.

It is for this reason that we are presenting, from the pen of a barrister experienced in the subject, a summary of what might be termed the reading of the new Law. We would recommend the careful perusal of the author's arguments, but as far as the reinforced concrete specialist in particular is concerned, we might say in short that in our opinion the new Act might probably be read as follows :—

The owner of the A system can prevent his licensee B from using unpatented systems—i.e., systems in general use not subjected to patents, but he cannot prevent B from using C's patented system; or, to revert to the well known case of Mouchel v. Cubitt, under the new law it would almost appear as if Cubitts could to-day (if they were still licensees of the Hennebique system) utilise, side by side with the Hennebique system, any patent system, such as the Coignet system or the like, but that they would be precluded from just putting metal rods anyhow—i.e., in a systemless manner into concrete with a view of reinforcing it, as long as the licence of the Hennebique system were held.

Thus it appears there can be no objection for a contractor to take a licence from half a dozen owners of specialist systems, but any one of the owners of these specialist systems could by the terms of a licence prevent the contractor using reinforced concrete in the ordinary sense, while not being able to prevent him using it in the specialist sense.

Indeed the wording of certain Acts of Parliament is wonderful!—ED.

ONE of the most important provisions of the new Patents Act is that dealing with licences and other contracts relating to patented articles and processes. The subject is one of considerable importance to specialists engaged in the application of reinforced concrete systems of construction, as was shown in the case of Mouchel *v.* Wm. Cubitt & Co., reported in CONCRETE of March, 1907.

Broadly it is the policy of the law to leave British subjects free to enter into any contractual arrangements they may think proper, and the fact that the new Patents and Designs Act restricts freedom of contracting, demands that the section which deals with it should be carefully examined and as clearly understood as possible.

SECTION NO. 38.

(1) It shall not be lawful in any contract made after the passing of this Act in relation to the sale or lease of, or licence to use or work, any article or process protected by a patent to insert a condition the effect of which will be :—

(*a*) To prohibit or restrict the purchaser, lessee, or licensee from using any article or class of articles, whether patented or not, or any patented process, supplied or owned by any person other than the seller, lessor, or licensor or his nominees; or

(*b*) To require the purchaser, lessee, or licensee to acquire from the seller, lessor, or licensor, or his nominees, any article or class of articles not protected by the patent;

and any such condition shall be null and void, as being in restraint of trade and contrary to public policy.

Provided that this Sub-section shall not apply if—

(i.) the seller, lessor, or licensor proves that at the time the contract was entered into the purchaser, lessee, or licensee had the option of purchasing the article or obtaining a lease or licence on reasonable terms, without such conditions as aforesaid; and (ii.) the contract entitles the purchaser, lessee, or licensee to relieve himself of his liability to observe any such condition on giving the other party three months' notice in writing and on payment in compensation for such relief in the case of a purchase of such sum, or in the case of a lease or licence of such rent or royalty for the residue of the term of the contract, as may be fixed by an arbitrator appointed by the Board of Trade.

(2) Any contract relating to the lease of or license to use or work any patented article or patented process, whether made before or after the passing of this Act, may at any time after the patent or all the patents by which the article or process was protected at the time of the making of the contract has or have ceased to be in force, and notwithstanding anything in the same or in any other contract to the contrary, be determined by either party on giving three months' notice in writing to the other party; but where any such notice is given determining any contract made before the passing of this Act, the party giving the notice shall be liable to pay such compensation as failing agreement may be awarded by an arbitrator appointed by the Board of Trade.

(3) Any contract made before the passing of this Act relating to the lease of or licence to use or work any patented article or process and containing any condition which, had the contract been made after the passing of this Act, would by virtue of this section have been null and void may, at any time before the contract is determinable under the last preceding sub-section, and notwithstanding anything in the same or any other contract to the contrary, be determined by either party on giving three months' notice in writing to the other party, but where any such notice is given the party giving the notice shall be liable to pay such compensation as, failing agreement, may be awarded by an arbitrator appointed by the Board of Trade.

(4) The insertion by the patentee in a contract made after the passing of this Act of any condition which by virtue of this section is null and void shall be available as a defence to an action for infringement of the patent to which the contract relates brought while that contract is in force.

(5) Nothing in this Section shall (*a*) affect any condition in a contract whereby a person is prohibited from selling any goods other than those of a particular person; or (*b*) be construed as validating any contract which would, apart from this section, be invalid; or (*c*) affect any right of determining a contract or condition in a contract exerciseable independently of this section; or (*d*) affect any condition in a contract for the lease of or licence to use a patented article, whereby the lessor or licensor reserves to himself or his nominees the right to supply such new parts of the patented article as may be required to put or keep it in repair.

THE INTERPRETATION.

The first Sub-section, above set out, like a good many others in Acts of Parliament, suffers from the draftsman's attempt to include a number of varied ideas in one sentence. The gist of it was perhaps more clearly expressed in an earlier stage of the Bill, when the Section read as follows :—

> It shall not be lawful in any contract made after the commencement of this Act for the sale or lease of, or licence to use, any patented article to impose as a condition of such sale, leasing, or licence to use a condition the effect of which will be to prohibit or restrict the purchaser, or hirer, or licensee from employing in his trade or industry any article or class of articles acquired from any person other than the person by whom the condition is imposed or his nominees, and any such condition inserted in any such contract shall be null and void.

But dealing with the Section as it stands in the Statute it will be seen, on analysing it, that the provision applies to any contract relating to the sale or leasing (that is hiring) of any article protected by a patent, and it also relates to licences to use or work any process protected by a patent. In such contracts it is so far forbidden to insert a condition the effect of which would be to wholly prohibit or merely restrict the purchaser, hirer, or lessee from using any article or class of articles, whether patented or not, supplied or owned by any third party.

The effect is the same if the prohibition or restriction imposed by the contract relates, not to the use of any articles, but to the use of any process, provided such process is patented.

The proviso at the end of Sub-section (1) amounts to this, that the first Sub-section does not apply if the patentee can show that the purchaser or licensee took the contract containing the conditions in question in preference to any other reasonable contract which did not contain such conditions; and if the contract containing the condition is subject to three months' notice whereby the purchased, hirer, or licensee can relieve himself from the condition on making reasonable compensation.

SUBJECT AND OBJECT.

It is very important to observe that the Section deals with contracts relating to articles and processes protected by patents, and not to the patents themselves, though, as we shall see directly, the distinction may disappear in the case of processes. But as to articles, a contract for the sale or hire of, say, a patented machine, is a very different matter from an assignment or licence of the letters patent. The machine is concrete; the letters patent grant a mere abstract property or right. Thus in contracts relating to such articles there need not, as a matter of fact, be any reference to letters patent at all, notwithstanding that they are the subject matter of such protection.

That the Section is intended to apply to the patented article and not to the letters patent itself is supported by Sub-section 5 (*a*). And Clause (*d*) of the same Sub-section tends in the same direction.

It is the custom with some firms owning patents not to grant licences to manufacturers to make the machines or other articles and sell them in the open market. Instead they manufacture the machines themselves or get them made, and then either sell them or let them out to their customers. They maintain the patent rights exclusively in their own possession, and they know exactly who are holding and using the machines. The Linotype is a case in point. The Linotype Company manufacture the machines in their own works and let them out on hire to the printers. Thus not even the machines themselves, let alone the letters patent, ever cease to be the Company's property.

It is with contracts dealing with the sale and hiring of such articles that the Section deals.

The system of selling, and still more of letting out, patented articles, is apt to lead to an undesirable state of affairs, in this way. The patentee having got a hold on his customer begins to press him to take improvements more or less real and accessories of some or no value for addition to the machine. The next step is to require the purchaser or hirer to obtain his raw material from the patentee, until the poor purchaser can hardly call his trade his own, and nearly all the profits are filched by the patentee. This is a most undesirable state of affairs, and the Act has a most excellent object in attempting to put an end to it. So far as the sale and hiring of articles is concerned it will probably succeed.

PATENTED PROCESSES.

But when it comes to processes the case is altered considerably. It will be observed that there is no reference to processes in the short draft Section above quoted; it was probably introduced with the idea of making the enactment complete. But a process is not a concrete thing like an article of manufacture; it is abstract like a patent right, and it is doubtful if, in this connection, any property can exist in a process apart from the property conferred by letters patent. The two become practically identical. One cannot very well sell, lease, or licence the use of a patented process without selling or granting a licence under the letters patent.

So far as patented processes are concerned, therefore, it would seem that the enactment goes much further than in the case of patented articles. In a contract relating to the sale or licence of a patented process, the Section renders null and void any condition the effect of which would be to prohibit or restrict the purchaser, lessee, or licensee from using any patented process owned by any person other than the seller, lessor, licensor, or his nominees. Nothing is said about unpatented processes, so apparently the seller or licensor may prohibit or restrict the use of these if he can identify them.

ARTICLES AND PROCESSES.

The question whether a licence under a reinforced concrete patent relates to an article or whether it relates to a process depends very largely upon the way in which the claims are drawn. A reinforced concrete structure is, of course, a manufactured article, but the invention may consist in the process by which that article is brought into being.

Take the case of a reinforced concrete specialist. He may have a patent on the subject, the essential feature of which is a novel bar. His claims may be drawn either for the bar itself, or for the process of construction embodying the bar, or it may be for both. In the first alternative, he could either make or sell the bars himself, or he could licence one or more firms to make and sell them and pay him royalties. If he sell them himself he must not make it a condition of the sales that the purchaser shall not use any other bar or the like supplied by any one else, that is, any one other than the patentee or his nominees; nor shall he require the purchasers to acquire from him or his nominees any article not protected by the bar patent; *unless* at the same time he, the patentee, gives the purchasers the option of buying the bars on reasonable terms without such conditions, *and unless* the contract entitles the purchasers to relieve themselves of their liability under the condition on giving three months' notice and paying certain compensation.

If the patentee of the bars grants licences to make and sell the bars, the licensees will be under the same restrictions, in contracting to sell the bars to their customers, as the patentee would be if he were selling them direct.

Suppose, however, that the claims in the patent specification are not for the manufactured bars, but for the manufacturing of reinforced concrete constructions by a process involving the use of the bars. Then the patentee has no specific patented article to sell, he can only grant licences to use or work his patented process. In such licences he is forbidden by the Act to insert conditions the effect of which will be to prohibit or restrict the licensees from using certain other processes—namely, patented processes owned by any person other than the licensor (*i.e.*, the patentee) or his nominees, *unless* the licensees have the option of taking an alternative licence without the conditions, and, if they choose the one with the conditions, then such conditions must be subject to termination on the licensees giving three months' notice and paying compensation. But the Act does not forbid the patentee to restrict or prohibit the licensees from using other processes that are not the subject of letters patent. So far as such unpatented processes are concerned, the licensor appears to be as fully at liberty now as he was before the Act came into force, to prohibit his licensees from using or working them.

ANOTHER EXAMPLE.

The object of the Section is not to restrict the patentee from profitably exploiting his letters patent directly, but to prevent his using his letters patent as a lever by which he may obtain indirect profits by coupling to his patent things in which he has no direct proprietary interest. Again, take the case of an inventor who has patented a machine for mixing concrete. If he grants a licence under his letters patent in the ordinary way, the licensee will be at liberty to manufacture the machines, to use them and sell them. Such a licence would be taken out by a machinery manufacturer whose object would be to make and sell the machines, but not to use them, except in a special sense. This would be a very different matter from the inventor selling or letting out one of his machines to a firm of contractors whose interest would be, not in making and selling but in using the machine. The Act applies to the second case, but not it is believed, to the first.

Seemingly, if the patent referred not to the mixer but to the process of mixing, the inventor in granting a licence to use the process would not be at liberty to restrain the licensee from using any other patented process; so, as before stated, he might not prohibit his using any patented process belonging to some person other than himself, the patentee. The patentee, in granting the licence to the machinery manufacturer, would still be within the law and his proper rights in inserting a covenant by which the licensee agreed not to manufacture any other concrete mixers than the one described in the inventor's specification. But in the second case the patentee would not be justified in stipulating in the agreement for the sale or letting of the machine, that the purchaser or hirer should buy from him, say, the shedding to cover the machine, or the lime to be used in it.

DETAIL CONSIDERATIONS.

Although it has been assumed in the above remarks that the person who sells, lets out, or grants licences is the person who is for the time being owner of the letters patent, or at least has a distinct interest in it, the Section is not confined to such, except as to Sub-section 4. It expressly refers to *any* contract made after the passing of the Act in relation to the sale or lease of or licence to use or work, etc. But to give the Section any wider interpretation than that above adopted would involve very great difficulties, as a very large number of contracts deal with patented articles in which neither the one party nor the other has any direct interest.

It could never have been contemplated, for instance, that the Section should apply to the hiring by a farmer of a threshing machine because the engine boiler happened to be fitted with a patent water gauge. On the other hand, the Act was doubtless intended to apply to such a case as the sale of an incandescent mantle being burdened with a condition that the mantle should only be used in conjunction with fittings supplied by the owners of the mantle patent. In the latter case the patentees are interested, in the former they are not.

The question as to what articles and processes are or are not protected will probably be decided on a *prima facie* basis; and letters patent professing to cover an article or process will probably be held to do so, in this connection, until the contrary is proved.

Sub-section 2 provides for determination on 3 months' notice of contracts relating to patents which have ceased to be in force. It is not generally known, perhaps, that in the absence of provision to the contrary a licensee is liable to continue paying royalties under a patent after it has been held invalid by a competent Court; but such is the case, or at least was, prior to the 1st of January last, and it is points like this that make the calling in of professional assistance so necessary in the preparation of contracts relating to patents. Even now a licensee who serves such a notice will be liable to pay compensation.

Sub-section 3 applies the restriction to contracts existing before the Act on either party giving the other 3 months' notice, and again subject to compensation.

Sub-section 4 discloses another pitfall into which a layman may fall if he attempts to prepare his own contract, as the inclusion of a forbidden condition may be held to provide a loophole of escape for an infringer who would otherwise be liable in damages.

There can be no doubt that the Section means the termination of a very inimical practice that was assuming dangerous proportions.

REINFORCED CONCRETE BUILDING FOR THE McGRAW PUBLISHING CO. NEW YORK, U.S.A.

In our issue of March last we presented technical details of an important ten-storey reinforced concrete structure at Pittsburg, U.S.A. We here present the building which is known as the McGraw Building and which is the home of the "Engineering Record" of the U.S.

Our engineering contemporary stands high in its influence throughout the American continent, and we need hardly say that the fact of its own building being in reinforced concrete, will materially emphasise the value that the Engineering professions have accorded to this form of construction in the States.

The building is an interesting one in many respects, and for this reason we are presenting the illustrations in considerable detail.

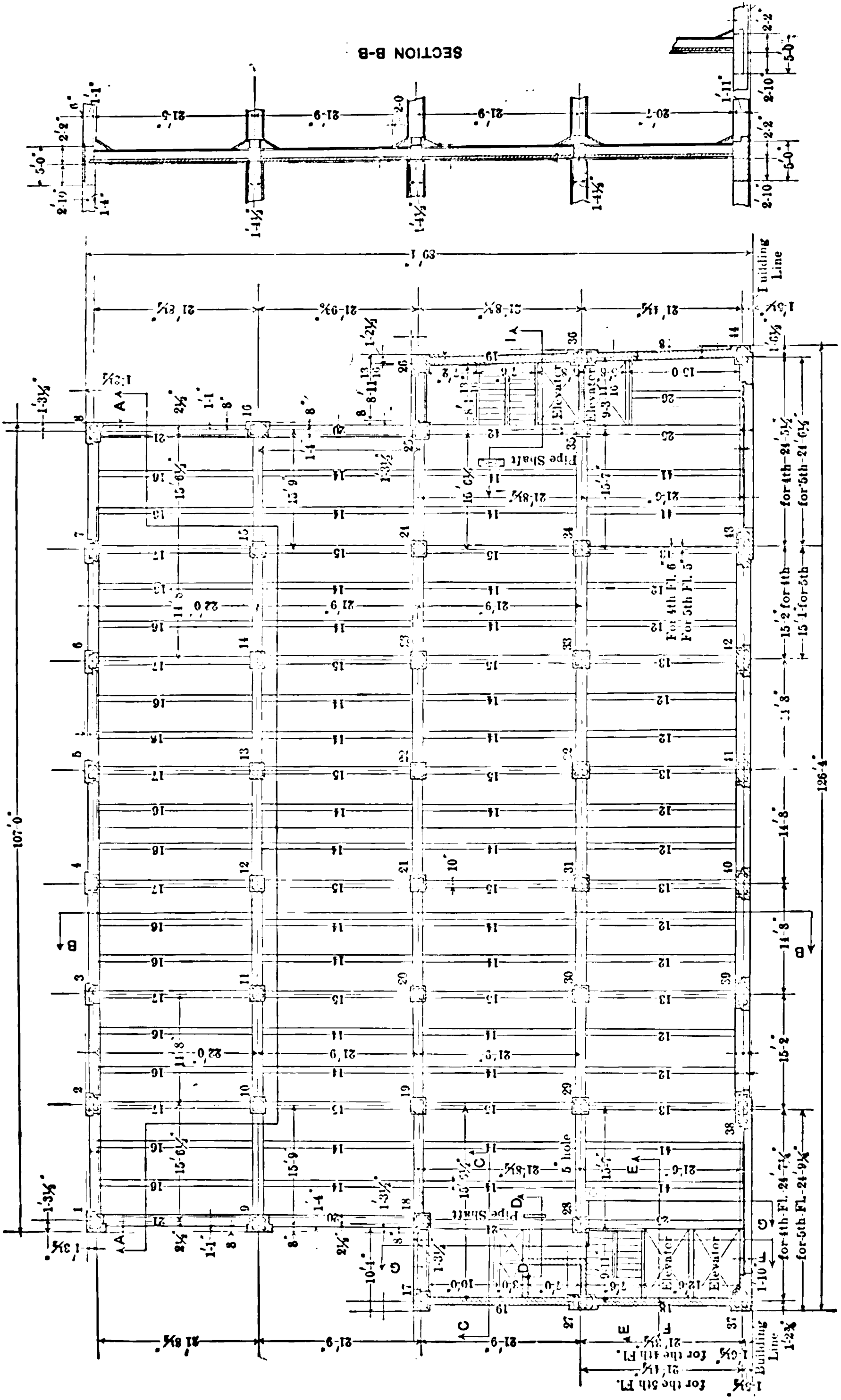
That we are able to do this is due to the courtesy of the proprietors of the "Engineering Record," who kindly put every possible detail at our disposal for the description of their new home.—ED.

From Notes by Professor WM. H. BURR, U.S.A.

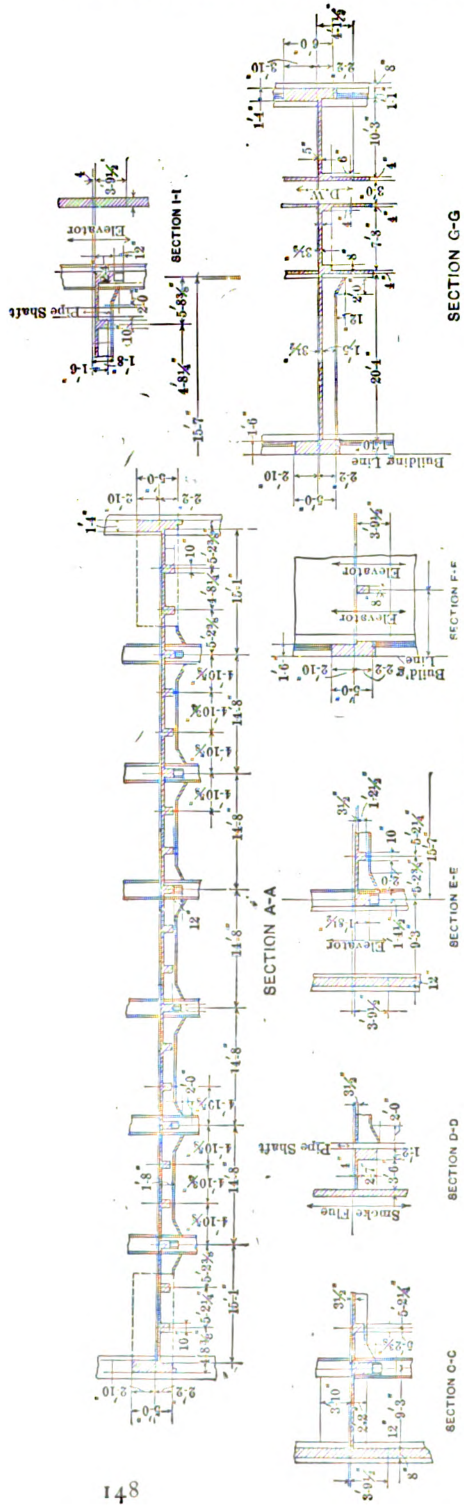
THE McGraw Building is a true reinforced concrete structure—the latest type of buildings of that general class. It is on the north side of West 39th Street, between Seventh and Eighth Avenues, in the city of New York, in that district which has already felt the stimulating influence of the new Pennsylvania R. R. Station in process of construction a half dozen blocks to the south. This part of the city is undoubtedly destined to become a great business centre, where substantial buildings of the highest type will be required in order to meet the demands of the development of that vicinity.

The building has a frontage of 126.3 ft. on 39th Street, and a depth of 90 ft. It has eleven storeys. The height of the roof is 145 ft. above the ground floor, or nearly 150 ft. above the street, or, finally, 159 ft. 6 in. above the basement floor. While, therefore, it is far from ranking among the tallest sky-scrapers of the city, it is to be classed among the high business buildings of Manhattan Island. Its height is much greater than has heretofore been considered practicable for a purely reinforced concrete building, *i.e.*, a concrete building without iron or steel columns.

It has been constructed for the McGraw Realty Co. primarily to accommodate the business of the McGraw Publishing Co., whose publications include the *Engineering Record*, *Electrical World*, and *Street Railway Journal*. At the same time it was designed to accommodate not only the printing presses of the McGraw Publishing Co., but any other similar business requiring the operation of heavy machinery or the storage of heavy goods in bulk. It was imperatively necessary,



McGraw Building, New York, U.S.A. (General plan and section of typical floor).



McGRAW BUILDING (Sections of typical floor).

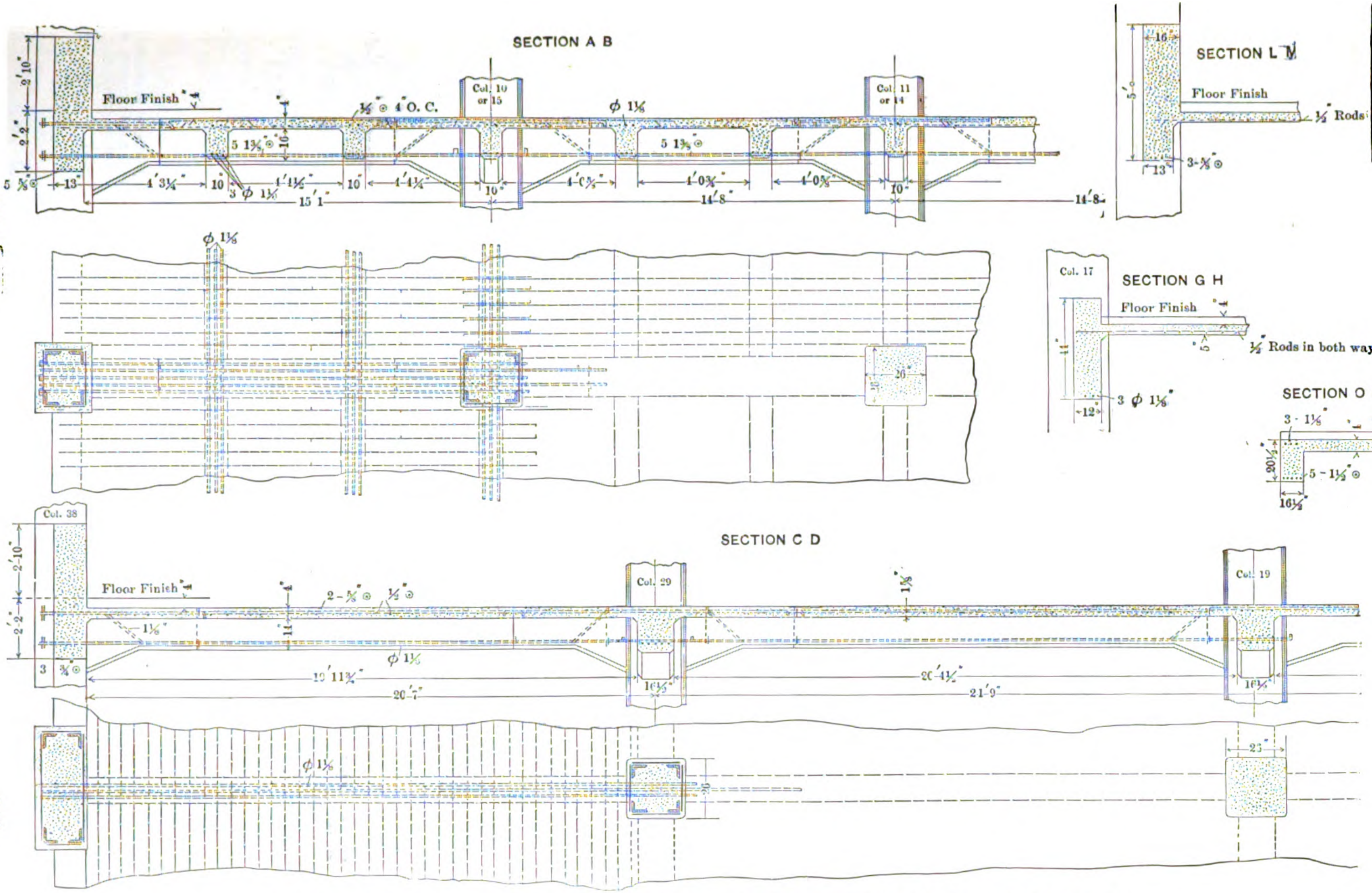
therefore, that the building should be designed and built so as to afford the greatest possible resistance to the vibration of heavy machinery, and possess to an unusual degree both rigidity and durability. It is also fireproof to such an extent that the McGraw Realty Co. may reasonably be its own insurer. While the building is admirably adapted to office use, its lower floors, particularly, are thus capable of affording provision for those business purposes which require heavy and substantial construction.

Like most other portions of that part of the city north of 14th Street, the rock originally at the site of the building was close to the surface. The excavations for the foundation were not carried deeper than about 20 ft. below the street surface, and there the entire foundation was placed upon the gneiss which forms the ledge or bedrock. There were no real foundation problems to be solved. The columns supporting the building, and the retaining or area walls around the basement, were all founded upon the same ledge, under the requirements of the Building Code of the City of New York.

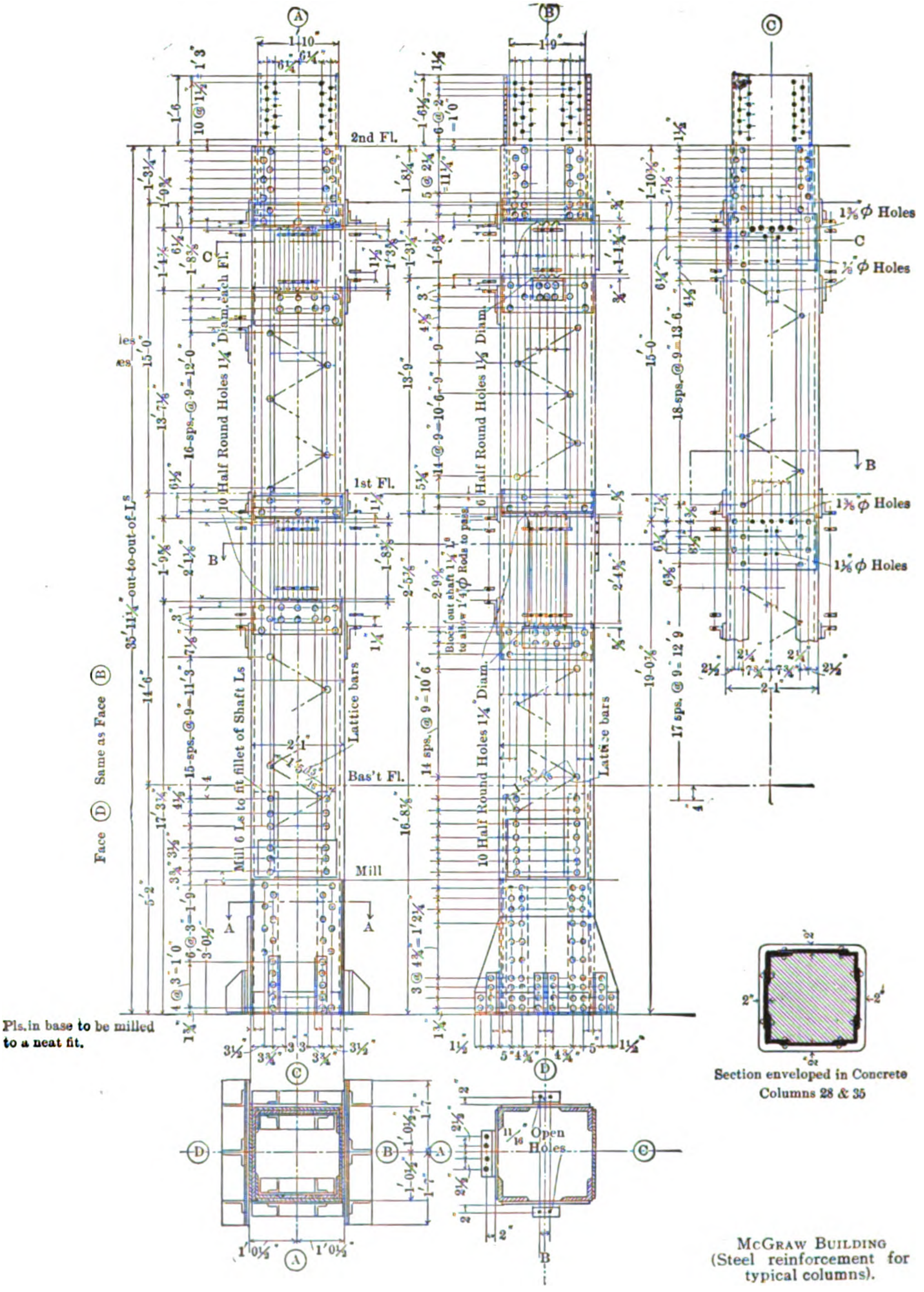
DESCRIPTION.

In order to meet the exacting requirements for the unusually substantial structure required by the McGraw Publishing Co., it was decided to design the building for a live load of 250 lb. per square foot for the first and second floors, 200 lb. per square foot for the third floor, 150 lb. per square foot for the fourth floor, and 125 lb. per square foot for all the other floors above the fourth, and with a live load of 60 lb. per square foot for the roof. All parts of the floor beams and girders, therefore, and the columns, were designed to sustain, under the requirements of the Building Code, the actual weight of the structure and the live load specified above.

Prior to the submission of this design the Building Code of the City of New York had permitted a working stress of only 350 lb. per square inch, for concrete in direct compression, it being practically assumed that all reinforced concrete columns would be of the Considère type. Obviously, if this regulation should prevail for an eleven-storey building, the size of the columns in the basement and lower stories would be so great as to trench too seriously upon the available space for machinery or for other business purposes. As it was strongly



McGraw Building, New York, U.S.A. (Sections of typical floor beams and girders, showing steel reinforcement).

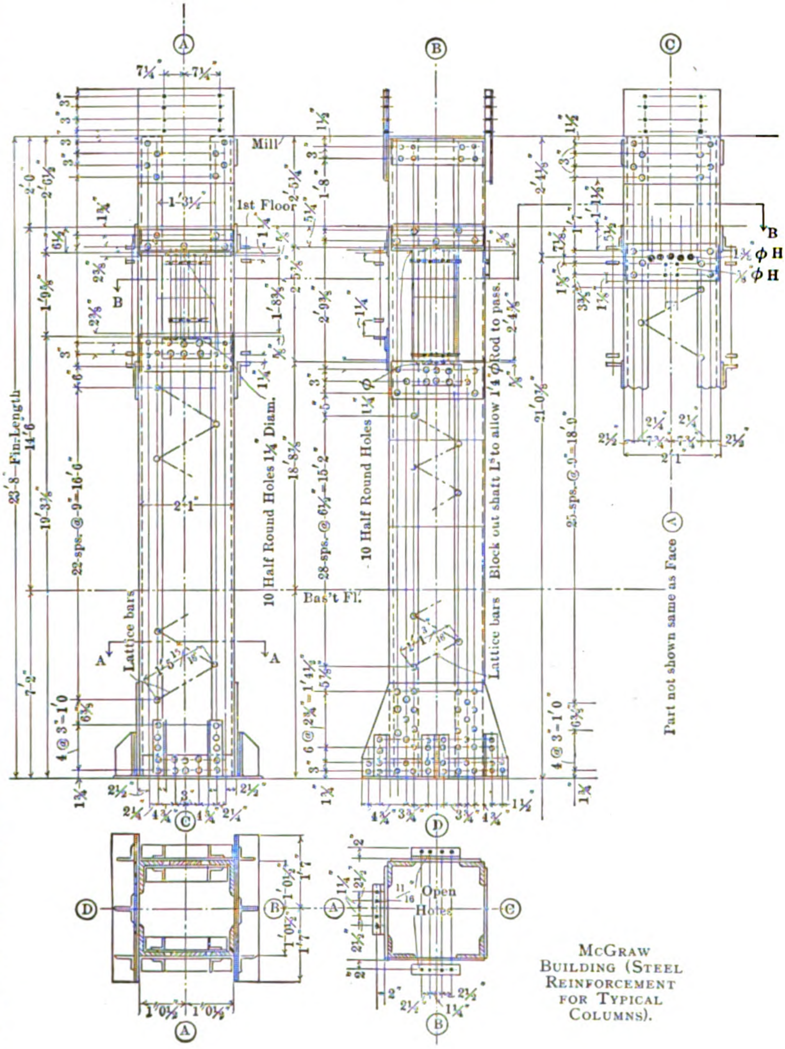


Pls. in base to be milled to a neat fit.

Section enveloped in Concrete Columns 28 & 35

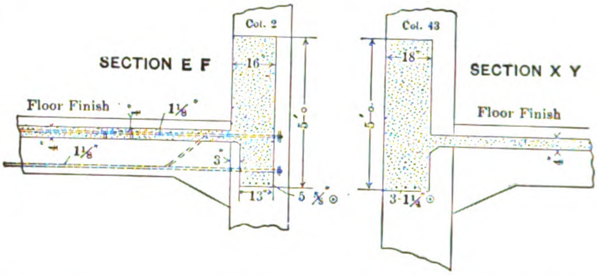
McGRAW BUILDING (Steel reinforcement for typical columns).

desired to secure all the material advantages accruing to reinforced concrete structures, it became necessary to design such columns as would be of much smaller cross-section than those of the type heretofore prevailing. Two procedures were available: one was to use a substantial quantity of steel in the form of an ordinary steel column suitably designed for this purpose, and the other was to use the concrete in such a way as to justify a much larger working stress per square inch than that prescribed in the Building Code. These requirements are met in an eminently satisfactory way by the columns of the type used. All columns throughout the building are composed of an interior filling of concrete, combined with steel angles latticed in the ordinary manner of built steel columns. The interior columns and most of those in the exterior walls are built with four angles, with the usual riveted lattice or lacing bars on the four sides of each column. In the case of a number of the exterior columns it was necessary for the attainment of unavoidable structural ends, to use a column of elongated cross-section with eight steel angles of the same general type as those in the interior, which, with the concrete filling, form a column of two cells, so to speak, rather than one. The plans accompanying this paper show fully and clearly this arrangement of the combined concrete with steel angles and lacing bars. In all cases the steel angles, with the corners of the angles turned out, were spaced as far apart as the extreme outer dimensions of the completed column would permit.



McGraw Building (Steel Reinforcement for Typical Columns).

In accordance with the requirements of the Building Code, there is a thickness of 2 in. of concrete outside of the steel angles. This 2-in. shield of concrete is assumed to carry no load whatever; its function is simply that of fireproofing, *i.e.*, to protect the steel against the immediate heat or flames of any fire that may start in the combustible materials at any time stored in the building, or of a conflagration in an adjoining building. The concrete within the exterior dimensions or outline of the steel angles is available for carrying a compressive or column load. As it is completely embraced or surrounded by the steel angles and lacing bars, it is steel "banded" in the most effective manner possible. Its enclosure in the steelwork of the column is so rigid, manifestly, that lateral strains under column loads must be greatly reduced—in fact, nearly prevented—within any ordinary limits of loading. Such concrete, therefore, is largely prevented from the usual yielding of that material under compression, and its compressive carrying capacity is increased. This is not only obvious from the condition of the concrete in these columns, but that view is confirmed by the comparatively few results of tests of concrete columns of this character. When, therefore, the plans of these columns were submitted to the Bureau of Buildings of the City of New York for examination and final approval, a special regulation was made permitting the concrete to carry a maximum working load of 750 lb. per square inch within the exterior limits of the steel angles, the exterior 2 in. of concrete, as stated previously, being considered simply a fire-protecting shield. This increased permissible load upon the concrete is coupled with the further provision that the cross-section of the steel in any column at any floor shall be sufficient to carry the entire dead load above that section without stressing the steel to more than 16,000 lb. per square inch.

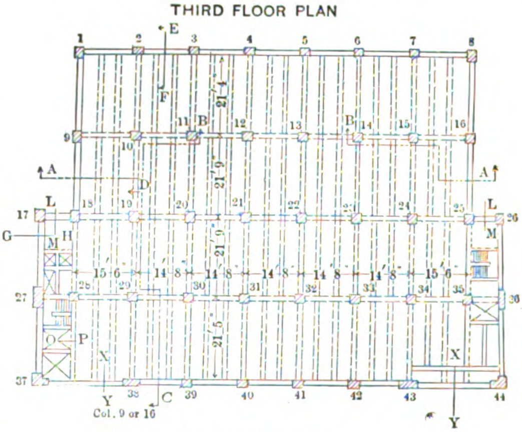


The use of the steel, in load-supporting condition, as a long column independent of the concrete, and at the same time forming a rigid banding member for the latter, with the consequent increase of permissible working load on the concrete, reduced the size of the columns in the basement and lower stories to dimensions quite consistent with the desired convenient and economical use of the clear floor space. Columns of this general type combine with their high carrying capacity great convenience in erection, for their steel sections may be erected ahead of the concrete work and afford convenient supporting members for the adjoining forms or for other erection work. The lacing bars, rivet heads, and other projecting column details act positively in creating a firm and complete hold or bond between the steelwork of each column and the concrete enclosed within it. This feature of these columns compels the steel and the enclosed concrete to act as a unit, and this action is enhanced by placing all the lacing bars in one direction inside the steel angles, the other set being placed outside, as shown on the plans.

The Building Code requires the ratio between the moduli of elasticity for the steel and concrete to be taken as 12. Hence, as the permissible compressive working stress in the concrete was taken at 750 lb. per square inch, the corresponding working stress in the steel would be 9,000 lb. per square inch.

The largest columns (in the basement) have exterior dimensions of 29×29 in., but, at the eleventh storey, the exterior dimensions are reduced to 14×14 in. These columns were built in sections of a length equal to the combined height of two stories, *i.e.*, 25 ft. The extra metal involved in this procedure was too small to be of practical consequence, and the expense of half the joints, if a change of section had been made at every floor, was saved. Much time was also gained in the erection of the steelwork. The abutting ends of the column sections were faced, and the joints were made by suitable splice-plates. Where there was a change in the exterior dimensions of the steelwork, full-strength splices were made by riveting suitable short-angle sections on the interior of the splice-plates of the lower part of the joint. These details are also shown on the plans.

The ratio of the area of steel section to that of the concrete for the various columns varied from 10 per



McGraw Building.

cent. in the basement where the steel carries about 57 per cent. of the total load to 3½ per cent. in the ninth floor where 30 per cent. of the total load is carried by the steel. The requirements of the Building Code for a design of this type raises the percentage of steel to much higher values than in ordinary concrete-steel work.

The design of the floors, in general, is quite similar to that usually found in buildings of this class, although there are certain important details which do not come under that observation. As the plans indicate, the spacing of the columns is such as generally to divide each floor into panels 21 ft. 9 in. by 14 ft. 8 in. between centres of columns, the clear span of the main girders between columns being 14 ft. 8 in. less the width or diameter of the column section. The clear span of the floor beams between the main girders is 21 ft. 9 in. less the width of these girders. These prevailing lengths of spans of the beams and girders were modified at a few points in each floor to accommodate such features of construction or details of floor space as stairways, elevator shafts, and similar details.

As the plans indicate, all floor-girder and beam reinforcement was of round steel rods, of sizes running generally from ¾ to 1 in. in diameter. These rods were grouped in one plane on the tension side of each beam or girder. As a rule, every alternate rod was bent upward at the end of each span so as to rise within about 2 in. of the top of the concrete, from which point it continues through either the main girder or the adjoining column, as the case may be, into the adjoining span well toward the quarter point of the latter. By these means true continuity of beams and girders was secured in every case. In addition to this, the end of each rod was bent down, forming a right-angled turn, with an arm from 2 to 3 in. long, thus insuring a rigid bond or connection with the concrete. This main detail, formed by carrying the rods through the girders and columns, is an important feature in securing continuity and rigidity in the general construction of the building. It is believed to be one of the most important details of the best design of reinforced concrete building construction, and it should be secured either in the manner adopted in this building or by some other procedure of at least equal excellence.

The proper spacing of these reinforcing rods was secured by suitable supporting details throughout the length of the beams and girders themselves and by notches cut in angle-brackets riveted on the columns where they joined the latter members. At the columns, rigidity of connection was secured by bolting clamps through the angle-brackets just named and jamming the rods by tightening the nuts against those brackets. This secured an exceedingly strong metal connection between the reinforcing rods and the steel columns, aside from the further rigidity produced by the concrete mass of the intersecting columns, beams and girders. These details, shown on the plans, were designed with care for the purpose of securing the strongest possible steel connections between the beams or girders and columns, and floors and outside walls. It is believed that unusual stiffness and strength have been given to this building by these means.

CONCRETE.

The proportions of the concrete for the entire building were: One of cement, two of sand, and four of broken stone or gravel by volume. The consistency of the concrete was very nearly or quite wet enough to be that termed semi-liquid, so that it was truly "poured" into all forms for columns, walls and floors. Such a consistency of concrete is imperative for reinforced concrete construction of this class. It enables the concrete to form an intimate and dense matrix around the steel reinforcement, and produces a most excellent quality of material. While the concrete was being poured labourers with long thin sticks continually agitated the fresh concrete in order to release all air bubbles and insure a dense and continuous product and the best possible bond with the embedded steel. There was no sensible excess of water in the concrete, but it was practically semi-liquid—too thin even to quake. The results throughout the entire work, in this respect, have proved to be in the highest degree satisfactory. The total quantities of the principal materials used were: Cement, 8,500 bbl.; sand, 3,000 cu. yd.; broken stone, 4,300 cu. yd.; gravel, 1,066 cu. yd.; steel in angle columns, 655 tons, latticed; steel in round reinforcing rods, 507 tons.

WATERPROOFING CONCRETE.

By W. LAWRENCE GADD, F.I.C.

The subject of Waterproofing Concrete seems to have been much neglected. We are for this reason presenting some articles on the subject, the first of which is by a Chemist, for in the main we must assume that Waterproofing Concrete is a chemical question.

It would be of value to our readers if the experiences of others were put at our disposal, so that we could quote instances not only of the defects met with, but also the remedies.—ED.

HITHERTO, all attempts to render concrete or cement work impervious to water, appear to have been made in one of three directions :—

1.—By painting the surface of the concrete, or cement, with bituminous compounds, such as asphalt or other water repellant, the object being to prevent water from coming in actual contact at all with the work.

2.—The application of washes to the surface of the hardened concrete, the one wash to react with the other, with the object of filling the surface pores with a precipitated insoluble compound.

3.—The addition of small quantities of insoluble substances to the cement or concrete itself, in order to fill the pores of the entire mass, or of the surface coat or rendering, with finely divided insoluble matter.

The first method needs but little comment, and includes the application to the surface of the work of any impervious material, such as pitch, tar, asphalt, presumably in a heated condition; also paint, varnishes of various kinds, and similar substances.

On the principle of method No. 2, the following applications have been tried :—Sylvester's process : A hot solution of soap, prepared by dissolving ¾ lb. of Castile soap in 1 gallon of water, is first brushed over and into the surface of the concrete, and allowed to dry for 24 hours. At the end of that period a second wash, consisting of 2 oz. of alum dissolved in 1 gallon of water, is applied in the same manner. The alum solution should be at a temperature of from 60° to 70° Fahr. The double operation is to be repeated as often as necessary or desirable, but four such coats are said to be impervious to a head of 45 ft. of water.

In " Handbook for Superintendents of Construction, etc., etc.," the following cement wash is recommended for making a water-tight lining for cisterns :—A stock solution is prepared of 1 lb. " lye," 5 lb. alum dissolved in 2 quarts of water. One pint of this solution is stirred into a pail of water containing 10 lb. of cement, and the mixture is applied to the surface of the concrete with a brush.

Another method is to apply a rendering composed as follows :—

(1.) Portland cement 1 part, sand 1 part.
(2.) Portland cement 1 part, sand 2 parts, lime paste ½ part.
(3.) Portland cement 1 part, sand 3 parts, lime paste 1 part.
(4.) Portland cement 1 part, sand 5 parts, lime paste 1½ parts.

The surface of the rendering, composed according to one of the above formulæ, is brushed with a solution of 1 lb. " concentrated lye," 5 lb. alum, and 2 gallons water, in the proportion of 1 pint of this solution to 5 lb. of cement.

In principle the above-named methods are alike, and all depend upon the precipitation within the surface pores of the concrete, or outer coat, of insoluble alum soap, or hydrate of alumina, or both together. The last-named example, however, combines to some extent the method of pore-filling in bulk with sand and lime paste.

In "Plastering, Plain and Decorative," Miller recommends painting the surface of the work with a hot mixture prepared by mixing 20 lb. of chopped suet with 1 bushel of lime, and stirring up with boiling water. He assumes this mixture to be stearate of lime (lime soap), but, as a matter of fact, very little stearate of lime could be formed under these conditions, and the bulk of the fatty matter would remain in the free state. The method, therefore, amounts to painting the surface of the work with a mixture of grease and lime, and really falls under the same category as Method No. 1. In all these methods, which involve the application of surface washes, it is essential that the concrete should be in a dry condition before the various solutions are applied.

Under the heading Method No. 3, there are various processes recommended, some of which aim at filling the pores throughout the mass of the work, whilst others confine this operation to the whole bulk of the surface coat, or rendering, only.

Professor Hatt states that with a mortar composed of 1 part of cement to 2½ parts of bituminous ash, when alum and soap were mixed with the water used for gauging, the strength and hardness increased 50 per cent. and absorption decreased by the same amount. One half of the water used for gauging was a 5 per cent. solution of ground alum, and the other half was a 7 per cent. solution of soap. The alum solution was used first.

Cunningham proceeds on similar lines. He uses powdered alum equal to 1 per cent. of the combined weight of sand and cement. To the water used in the mix he adds 1 per cent. of yellow soap.

Hawley employed a stock solution of 2 lb. caustic potash, 5 lb. powdered alum, and 10 quarts water. A finishing coat was made with 3 quarts of this solution in each batch of mortar containing 2 bags of cement. The mortar was made with 2 volumes of sand to 1 of cement, and the work covered to a depth of ½ in.

Marsh gives the following as a waterproof coat or rendering:—2 lb. soft soap, 12 lb. alum, 30 gallons water per cu. yd. of the mortar. Or, 2 lb. caustic potash, 5 lb. alum, 10 quarts water. Of this solution 3⅜ quarts are used for 2 bags of cement and twice its volume of sand.

It will be observed that these processes again depend upon the precipitation of aluminium soap or of hydrated oxide of aluminium, the only difference being that, in these cases, the precipitate is mixed with the mortar instead of being deposited at the surface of the hardened material.

Gaines, in a paper recently published in America, states that watertight concrete can be made (1) by replacing the mixing water with a dilute solution of a suitable "electrolyte" (*i.e.*, a 1 per cent. or 2 per cent. solution of alum); (2) by replacing 5 per cent. to 10 per cent. of the cement with dried and finely ground colloidal clay; (3) by combining methods (1) and (2). With regard to the second of these processes, the action appears to be simply one of pore-filling with fine particles of clay, inasmuch as no "electrolyte" is used; and in the other cases it is probable that the same kind of action takes place by precipitation of alumina, from the "electrolytic" solution, by calcium hydroxide, whether the electrolytic theory itself be correct or not.

It may be remarked that the use of pulverized clay for this purpose is old, but, unfortunately, no very definite conclusions as to its value, or otherwise, were arrived at.

There are on the market certain ready prepared compounds for mixing with the concrete or cement in order to make it watertight. Some of these will now be noticed.

"Lux," Patent No. 4606 of 1904. This material is prepared by pouring over 100 kilos of cement clinker (unground) 10 litres of boiling water containing 245 grams of stearine, 12 grams of potash (presumably caustic potash, although it is not clearly stated), and 10 grams of colophony (*i.e.*, common resin). It is difficult to understand the rationale of this process, as so far as any reaction at all takes place the result would be potash salts of stearic and abietic acids, both of which are very water absorbing and soluble in water. The actual result, however, would be practically equivalent to grinding clinker with a certain proportion of tallow and rosin, plus potash, which absorbs water with avidity.

Gallagher's Waterproof Compound.—This material is to be added to cement in the proportion of 2 per cent. to 5 per cent. on the weight of dry cement before mixing with the sand and water. Its composition has been stated to be chiefly lime and magnesia, with about 3 per cent. of stearine or other fatty acid. If this material has any waterproof properties at all, it can only be (assuming the composition is as above stated) by virtue of filling the pores of the cement or concrete with finely divided lime and magnesia; and, as the amount to be added is so small, its influence in this regard would not appear to be very great.

" Pharos " Waterproofing Compound.—This is a product very similar to Millar's so-called " Stearate of lime," already mentioned .

The composition of a sample recently examined was found to be as follows :—

		Per cent.
	Free fat (tallow or stearine)	20·22
Lime soap	Combined fatty anhydrides	14·55
	Combined lime	1·57
	Lime	30·45
	Magnesia	21·15
	Hygroscopic water	3·32
	Combined water	5·77
	Silica	1·17
	Alumina and ferric oxide	1·18
	Sulphuric anhydride, etc.	·62
		100·00

" Pharos," in common with other substances of similar composition, possesses a certain amount of waterproofing action, or resistance to percolation, when mixed with a neat cement rendering in the proportion of, say, 5 per cent. on the weight of dry cement. This is partly owing to the pore-filling action of the lime and magnesia which form the bulk of the material, but probably more to the repellant action of the free grease. It is well-known, however, that in process of time greasy substances in contact with water lose this repellant property to a very large extent. Furthermore, the addition of greasy substances to cement has always been regarded as detrimental to the strength and permanency of concrete, and undoubtedly does have a deleterious effect in this direction as well as producing a tendency in the work to crack. The addition of 2 per cent. of " Pharos," for instance, was found to reduce the neat tensile strain by 40 per cent. It becomes, therefore, a question how far it is advisable to reduce the strength of concrete by such additions for the sake of an incomplete waterproofing quality.

It is possible that the best results may yet be obtained by some method of filling the pores or voids in the concrete, not necessarily with " water repellants," and to this end it is doubtless important that the character of the aggregate should be such that a minimum of voids is created in the concrete. In *Engineering Record* of January 28th, 1905, J. C. Hain emphasised this point and gave the following as a possibly ideal sand for use in concrete :—

SAND.

Size of Sieve	Percentage to pass through.
No. 8	100
Nos. 8 to 12	60·4
No. 12	39·6
Nos. 12 to 24	24·1
No. 24	15·5
Nos. 24 to 50	9·6
No. 50	5·9
Nos. 50 to 100	3·8
No. 100	2·1
Nos. 100 to 200	1·5
No. 200	·6

The same point is referred to by J. L. Davis, in a paper recently read at the Annual Convention of the American Association of Cement Users. He states that by scientifically grading the aggregate, water-tight tanks, with thin sides or walls, have been successfully built of 1 : 3 : 7 concrete; and that the results of tests carried out by himself show that a fair degree of impermeability can be secured by the use of a sufficiently fine sand, without special care in grading the coarser parts of the aggregate. Davis considers that the use of fine sand, together with crusher run stone, or ordinary gravel, as the coarse aggregate, and the usual proportion of cement, is a method of waterproofing of considerable promise. In some cases he found 1 : 3 mixtures to be absolutely impervious to water, at 40 lbs. pressure, when the concrete was twenty-eight days old.

It may be here remarked that concrete almost invariably becomes more impervious to water the older and harder it grows, and a mass or wall of concrete through which water readily percolates at first, may very possibly become, in the course of a few weeks or months, practically watertight.

No doubt there are cases in which the application of external waterproofing materials (preferably on the outer, or damp, face of the work, and elastic in its character) will be useful, and perhaps necessary; but for constructional work in general, and especially basement or foundation work, conduits, etc., it is probable (as already remarked) that the problem of waterproofing concrete will be most readily solved by the simple process of closing up the pores throughout the mass of the work. Possibly fine sand alone may not be the best material, and hydrated lime appears to be useless except in small proportions; or, in other words, is not equal to the same proportion of Portland cement as a pore-filler; but experiments, not yet completed, which are being made, point strongly to the general conclusion, and show that good results in the direction of impermeable concrete are obtained by the addition of comparatively small proportions of finely divided insoluble substances.

NEW USES FOR CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented as to new uses to which concrete and reinforced concrete are put, with data as to experience obtained during the experimental stage of such new applications of these materials. The use of reinforced concrete as a substitute for timber in exposed positions is one of the questions of the moment. Railway sleepers, telegraph posts, fence posts, etc., of concrete are being tried. Similarly, efforts are at present being made to prove that reinforced concrete is an excellent substitute for brickwork, where structures of great height are required.—ED.

REINFORCED CONCRETE ARMOUR-PLATING FOR MEN-OF-WAR.

THE idea of employing reinforced concrete as a substitute for steel in the construction of armour-plating for battleships was suggested by observations at the siege of Port Arthur. Heavy Russian shells, striking the concrete Japanese batteries, produced only pits on the surface, without giving rise to cracks, and this in spite of the fact that the Japanese concrete was of poor quality and prepared with an unsuitable aggregate. The quality of the concrete employed in the construction of the Russian forts at Kekuan-Nord and Erlung was even inferior to this, and yet these forts withstood the 28 cm. Japanese shells with success.

In considering the possibility of employing concrete for the armour-plating of ships, it must be remembered that whilst the specific gravity of Harvey-Krupp steel is 8·1, that of concrete is only 2·25 to 2·4, so that a much greater thickness can be used for the same weight.

Figs. 1 and 2 represent sections of an imaginary battleship of 16,950 tons displacement and 22 knots speed, the armament being 8 guns of 305 mm. and 12 of 120 mm. A 1 : 1 : 4 concrete is supposed to be used, composed of Portland cement, sand, and basalt or porphyry, broken to pass a 4 or 5 cm. ring. The armour is built up in three layers, of which the outermost *c* is richest in cement and is further hardened by chemical treatment. The layers *c*1 and *c*2 are less hard.

Figs. 3 and 4 represent a ship of the *Vittorio Emanuele* type, in this case reinforced concrete being the suggested plating. A thickness of 1·5 m. is considered sufficient to protect the ship against the impact of 305 mm. shells, impinging normally at an ordinary fighting range. The height of the armoured belt is 3 m., 1·5 m. of which is submerged. The deck above this belt is protected by a belt of concrete 1 m. thick. The concrete would be enclosed between two thin steel plates *a* and *b*, parallel to one another, which would serve to protect the surface from cracking, unless in the improbable case of several shells in succession striking the same point. The reinforcement would consist of a network of vertical and horizontal steel rods, and if desirable, also of one or more vertical sheets of metal.

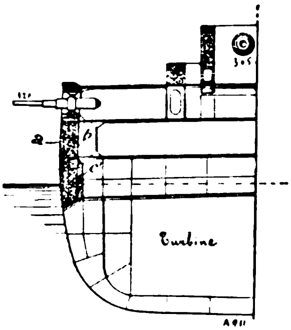


FIG. 1.

The adhesion of concrete to steel, and the equality of the co-efficients of thermal expansion of steel and concrete, are important factors in the suitability of the material to the construction of warships.

In a similar manner, concrete may be used for the protection of the turrets, casemates, and conning towers, the concrete being packed between the steel plates of the towers. In cases in which it is impossible to obtain a sufficient thickness of concrete, a layer of 30 to 45 cm. of concrete may be used in combination with steel armour-plate 10 to 15 cm. thick. The inventor and patentee of the system, Sr. Lorenzo d'Adda, prescribes certain precautions to be taken in the preparation and ramming of the concrete, and considers that three months should be allowed for the attainment of a sufficient degree of hardness. Portland cement of the best quality is the only cement permissible, the sand should be silicious river sand, and the aggregate should be either an igneous rock, such as granite or basalt, or a crystalline limestone, or travertine. The richer the concrete the greater its resistance, but also the greater the specific gravity. The crushing strength is not necessarily a measure of the resistance to projectiles, the force of impact being concentrated on a single point, with great tendency to lateral displacement. The enclosure of the reinforced concrete between steel plates enormously increases the resistance, by distributing the shock and by checking the formation of cracks. No projectile is capable of completely traversing, intact or in fragments, a thickness of 1·5 m. of well-made reinforced concrete. Again, owing to the low conductivity of concrete for heat, practically the whole heat developed by the impact has to be absorbed by the projectile.

The naval battle of August 10th, 1904, proved that projectiles are comparatively powerless, under the conditions of modern warfare, against armour-plating even of moderate thickness. The *Czarewitsch* was struck on the armoured belt by fifteen shells of 305 mm., not one of which succeeded in piercing a single plate. The *Nisshin* was struck on the armoured belt by a shell which pierced the 15 cm. Terni plate (*Fig.* 5), burst in the vacant compartment *a* without damage, and slightly deflected the steel wall of the coal bunker *b*.

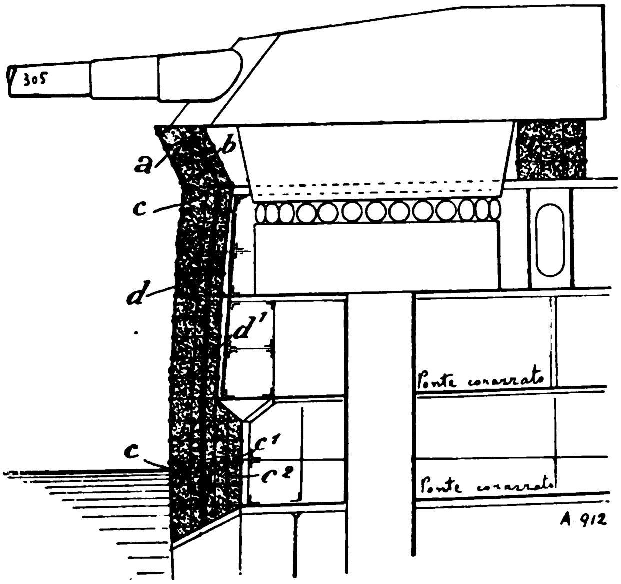


FIG. 2.

For Figs. 1 & 2.
a = External plating.
b = Internal plating.
c, c^1, c^2 = Layers of concrete of different hardness.
d = Reinforcement.

Italian experiments with shields of these materials have recently been made, and have fully confirmed the opinion of the great resisting power of concrete. A Firth projectile, weighing 117·5 kgs, having an initial velocity of 629 m., easily pierces a Terni-Krupp shield 254 mm. thick, but when fired against a Baratta shield (380 mm. reinforced concrete + 198 mm. Vickers steel, the resistance of the concrete being calculated to be one-sixth of that of a Terni-Krupp plate) only penetrated the plate to a depth of 4 cm.

The use of reinforced concrete for the protection of ships would involve a great diminution of cost. A cruiser costing 35,000,000 lire with steel armour would cost, if constructed on the new system, only 25,000,000 lire.

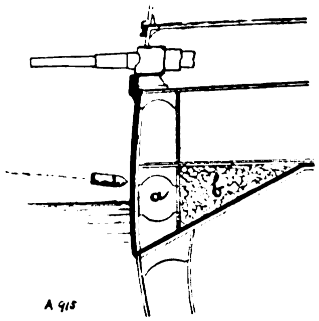


FIG. 5.
Manner in which the *Nisshin* was struck.

REINFORCED CONCRETE RAILWAY SLEEPERS.

We understand that the Italian State Railways, after experiments, have decided to employ sleepers of reinforced concrete on their lines, and a first lot of 300,000 sleepers have been ordered, at a cost of about 6s. 4d. each.

Experiments are also being made in Canada. particulars of which we hope to publish in an early issue.

REINFORCED CONCRETE BENCHES IN GREENHOUSES.

A novel use for reinforced concrete is to be found in the making of concrete benches for greenhouses. The bench is constructed on the portable principle. the sides, bottoms, cross-pieces, and supports all being made separately in different moulds, the bottom sections being hollow, with the edges tapered for drainage purposes. The concrete, except in the supports, is composed of 1 part Portland cement to 4 of gravel and sand, but for the supports a mixture of 1 part cement to 6 of gravel and sand may be used. The sides, bottoms, and cross-sections are reinforced with steel rods.

These benches have been in use at a horticultural establishment in Illinois, U.S.A., for upwards of two years, and have given complete satisfaction.

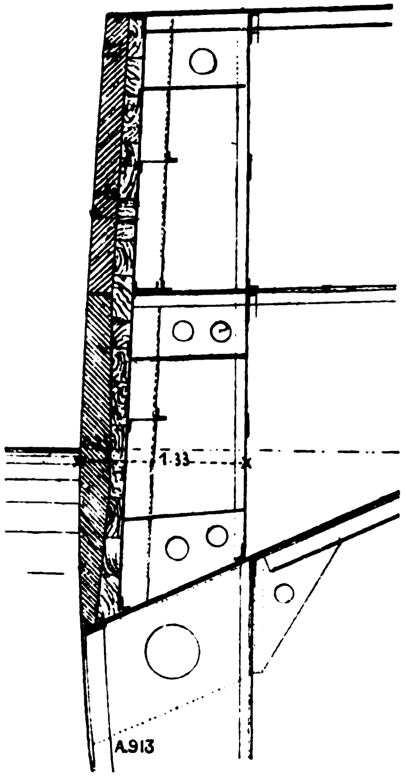


FIG. 3.
Vittorio Emanuele type, protected by Terni plates of 25 and 30 cm.

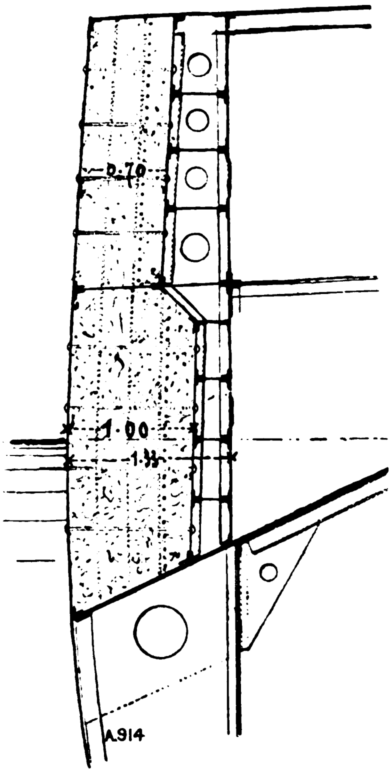


FIG. 4.
Vittorio Emanuele type, proposed protection by reinforced concrete 1 m and 70 cm thick.

NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course or construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

REINFORCED CONCRETE VIADUCT FOR THE MUNICIPAL GASWORKS AT COPENHAGEN.

(*Translated from the Danish.*)

THE Copenhagen Municipality has recently built a viaduct, which is to be used in conveying coal to the large new municipal gasworks at Valby, near Copenhagen.

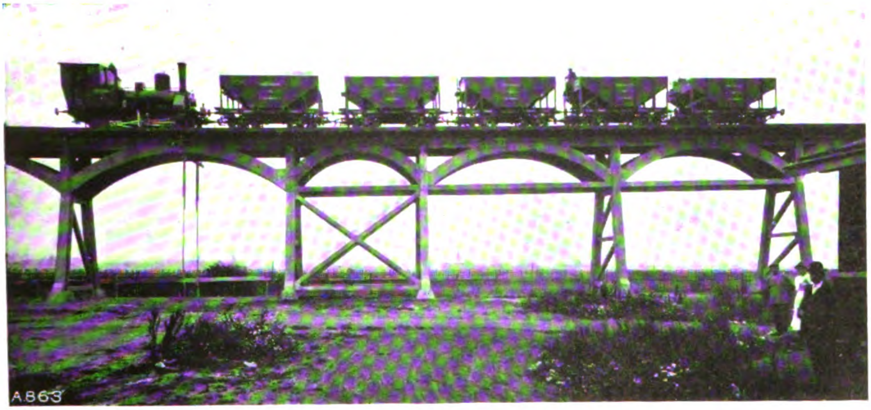
This coaling viaduct forms a continuation of an inclined earth embankment of which the highest point is about 11 ft. above ground, and from this point on to a level of 45 ft. above ground a standard-gauge railroad track having gradients of 1 : 45 and 1 : 100 is supported on the viaduct. The total length of the viaduct is 1,850 ft., and its highest portion (supports 54 to 69 on the diagram), where the track is level for about 510 ft., is located right opposite the retort house, so that the coal may be conveniently shot from the viaduct into the works. This process is, by the by, carried on by shooting the coal from the railroad cars into pockets, which are located under and between the rails and discharge into smaller cars standing on a lower deck, and from this deck the small cars convey the coal over short bridges into the retort house—*i.e.*, at right angle to the viaduct.

The viaduct was designed by Capt. T. Grut (R.Dan.E.) and is built of reinforced concrete on the Hennebique system.

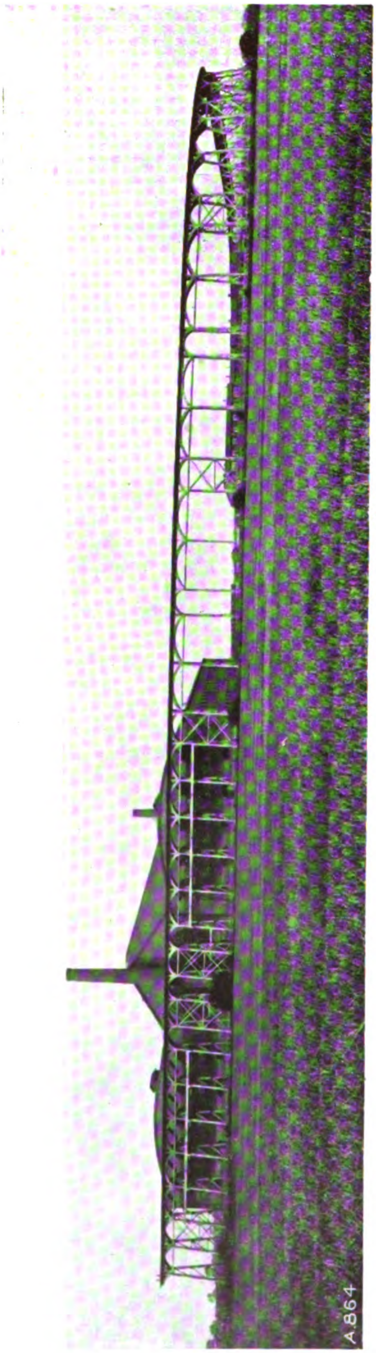
The viaduct consists of seventy-one arched spans, on seventy-one supports and on the abutment wall at the end of the above-mentioned embankment. The superstructure in each of the bays consists of two arches at an average distance, centre to centre, of 6 ft. 7 in., of four secondary beams transmitting the load partly to the arches and partly to the top of the supports, and of a solid floor, 10 ft. wide, supporting the track and resting partly on the secondary beams and partly on the arches at their crown. In most of the bays a tension member is provided to take up the arch thrust.

The depth of superstructure is alike in all the bays of the viaduct—viz., 8 ft.—and on the sloping portion the proper gradient is maintained by varying the height of the supports.

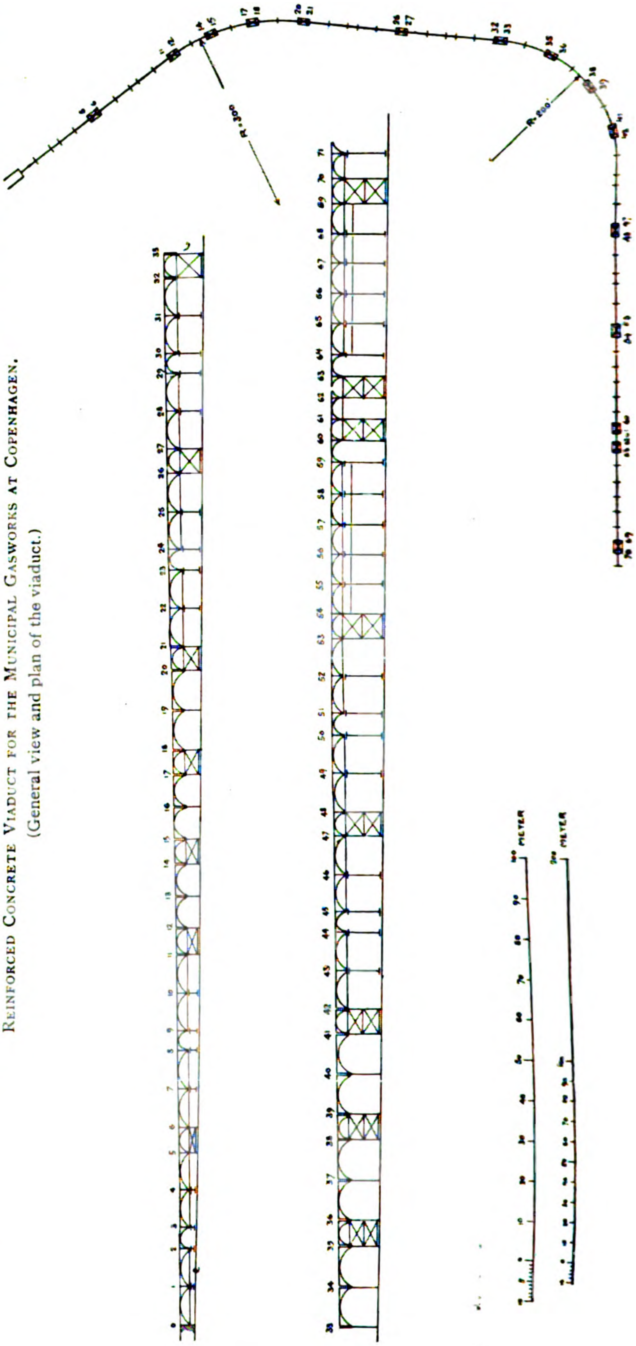
The ruling considerations in the construction of the viaduct have mainly been the horizontal lay-out in combination with proper provisions for the thermic expansion.



REINFORCED CONCRETE VIADUCT FOR THE MUNICIPAL GASWORKS AT COPENHAGEN.



Reinforced Concrete Viaduct for the Municipal Gasworks at Copenhagen.
(General view and plan of the viaduct.)



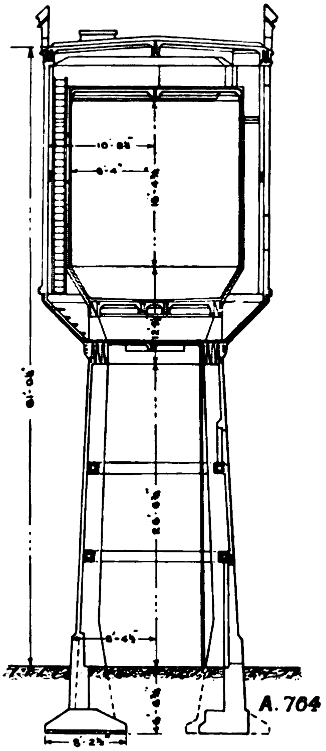


Fig. 1. Reinforced Concrete Water Tower in Austria.

In principle the design is different for the rectilinear and for the curved portions of the viaduct.

In the rectilinear part of the viaduct the superstructure is subdivided, by expansion joints, into sections 165 ft. long, and each such section consists of five whole and two half arches—namely, in the centre a 21 ft. arch, and on either side thereof two 32 ft. arches, and finally, at either end, one half 16 ft. arch, acting as a cantilever. The central arch in each section is fixed; that is to say, it is cast in one with its two supports, and these two supports, in their turn, are connected and made immovable by diagonal bracing in direction along the viaduct. Thus this central arch forms a fixed point in the corresponding section of the superstructure, and the two equal parts, on either side thereof, may now freely expand or contract from this point. This expansiveness is attained by making the four other supports hinged both at top and bottom, by inserting a strip of lead, 5/32 in. thick, between the supports and respectively the superstructure and the foundation.

The cantilevering half 16 ft. arch, at either extremity of the above-mentioned continuous section of the superstructure, and a similar half arch belonging to the next section of the viaduct, form an apparently unbroken complete arch, the connection between the two halves being effected by means of an expansion joint allowing longitudinal motion.

In the curved parts of the viaduct it was considered desirable to obtain as much stiffness as possible, and for this reason to make all the supports fixed. It was then necessary to take up the expansion in another way, and this was done by placing the above-mentioned 21 ft. arches on diagonally braced towers, closer together than in the straight parts of the viaduct, and by constructing the intermediate bays as continuous elastic arches, free to rise or drop by changing temperature. In these bays the supports and the arches are cast together, but the upper parts of the supports, from the skewbacks to the bridge floor, are split in direction across the viaduct, so as to provide an expansion joint between the two halves. For these elastic arches it was, of course, necessary to omit the tension rods.

The viaduct is calculated to carry a load consisting of two locomotives followed by fully loaded cars. In the calculations an allowance for impact is made by adding 20 per cent. to the rolling load. The wind pressure is figured at 55 lbs. per sq. ft. The calculations are based on the assumption that the arches with tension members are fixed at both ends, while the continuous 26 ft. or 33 ft. arches are supposed to be firmly fixed at their outer supports, while the central support is considered to be a roller bearing.

We are indebted for the foregoing information and illustrations to Captain T. Grut and Lieut. Hoff, of Copenhagen.

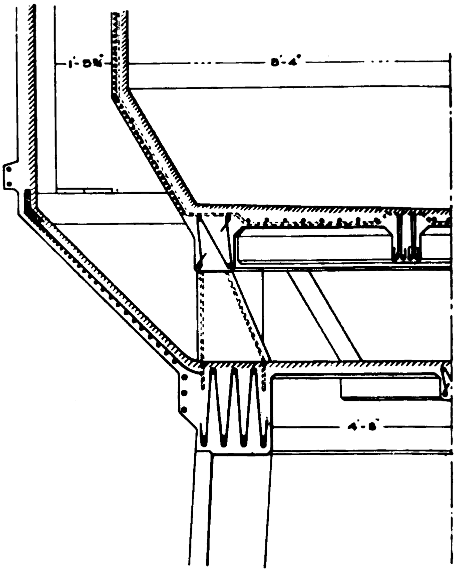


Fig. 3. Details of Reinforced Concrete Water Tower.

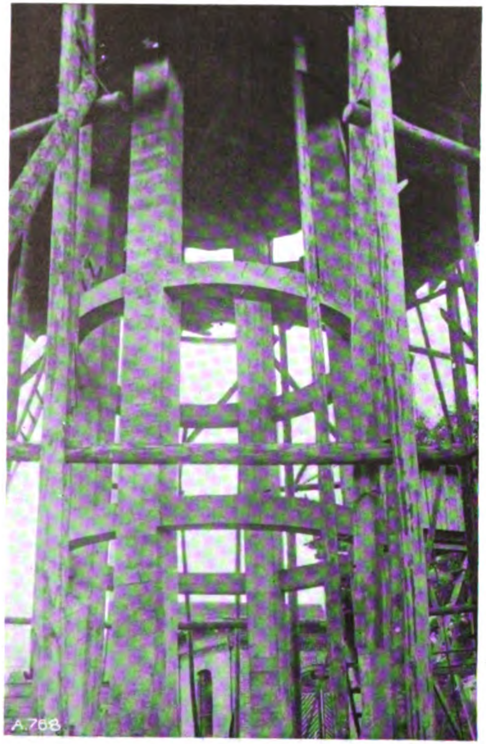


Fig. 2.

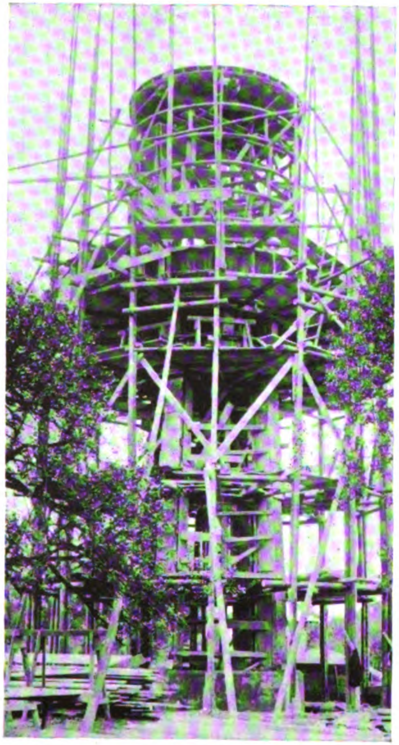


Fig. 7.

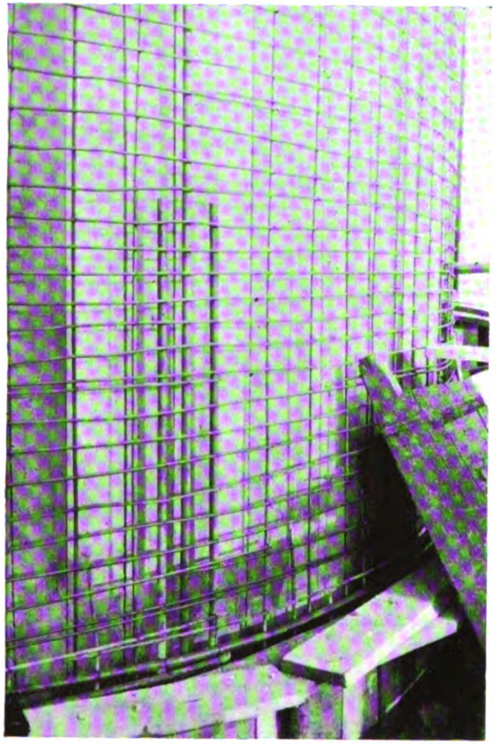


Fig. 8.

Reinforced Concrete Water Tower in Austria.
(In course of construction.)

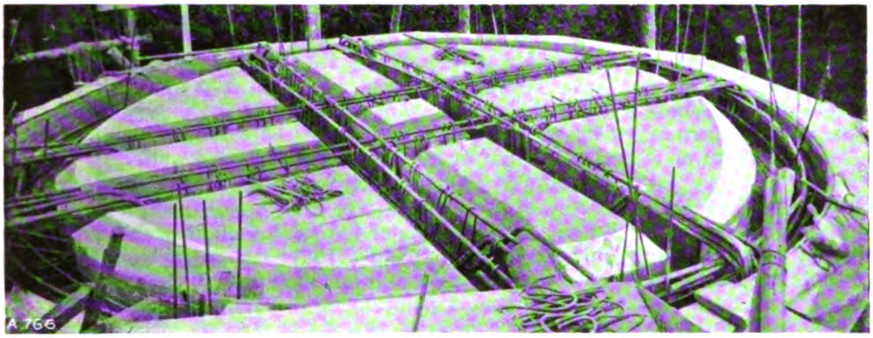
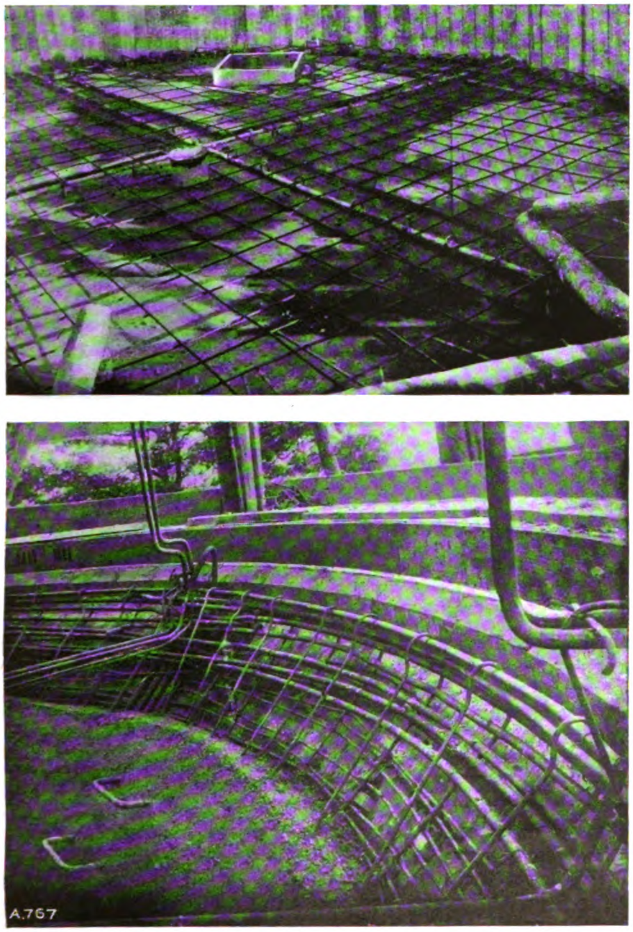


Fig. 4.



Figs. 5 and 6. Reinforced Concrete Water Tower in Austria.
(Showing reinforcement.)

A NEW AUSTRIAN WATER TOWER.

The difficulty of securing a constant water supply for the two Austrian communes of Hard and Fussach, lying in the Rhine delta close to the Lake of Constance, has led the authorities to erect a water-tower, illustrations of which we now give. Reinforced concrete was selected as the mode of construction, and the work was designed and carried out by Messrs. Linfold & Schneider, the tower being completed and made ready for use in the remarkably short time of ten weeks.

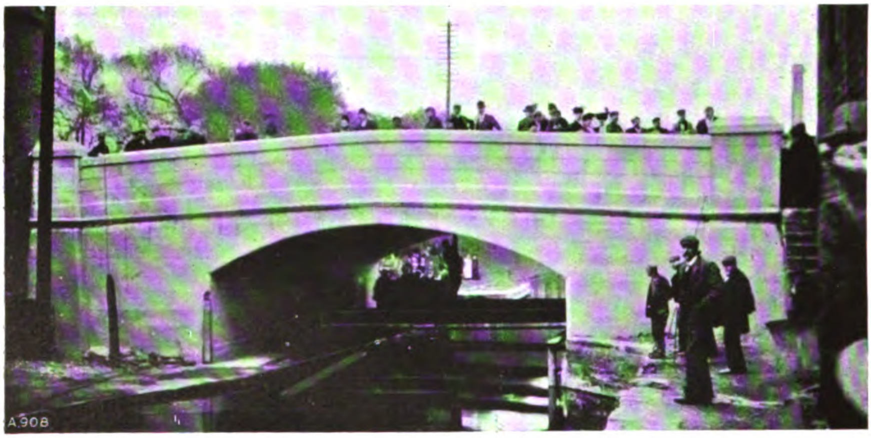
The illustrations show the general character of the design. The foundation being in soft, alluvial ground, a reinforced concrete sole was used, on which a plain concrete pedestal, shown in the section (*Fig.* 1), was raised. Four reinforced columns were erected as main supports, their light construction being compensated for by the hoops connecting them at intervals (clearly seen in *Fig.* 2). The cross-beams were arranged with basketlike ends (shown in *Fig.* 3) to carry the reservoir, the floor of which is shown in different stages in *Figs.* 4, 5, and 6, whilst the construction of the reservoir itself may be seen from *Figs.* 7 and 8. Although the reinforcement throughout is very light, its distribution has been carefully planned, and the measurements of loading tests and of the deflection under the strong wind prevalent in the district were entirely satisfactory, no permanent deformation whatever being observed.

The entire tower is enclosed in an outer 5-in. casing of brickwork.

FIRGROVE BRIDGE, ROCHDALE.

THERE are several details worthy of note both in the design and in the erection of the bridge at Firgrove. The old stone bridge was of the semi-circular arch type, and was extremely narrow, being only 13 ft. 6 in. wide between the parapets at the centre of the arch: the roadway over the bridge was what is termed "camel-backed." In the design of the new bridge this was a point to be carefully considered, as it was desirable to keep the crown of the road down as low as possible, while at the same time the head-room from the water level of the canal was fixed.

This old bridge was replaced by a complete reinforced concrete structure, the arch of which has a net width of 42 ft. As will be seen from *Fig.* 1, which is a general plan showing the situation of the new bridge and indicating the outlines of the old bridge, the new one will constitute a great improvement, for, in addition to providing for two lines of vehicular traffic across the canal and enabling the borough engineer to effect a widening of the two thoroughfares converging upon the eastern approach, it is able to carry and cope with all and every vehicle of modern traffic. *Figs.* 2, 3, 6, and 7, are sections making clear the general nature of the construction.



REINFORCED CONCRETE BRIDGE AT ROCHDALE.

As the subsoil consists of gravel overlying strata of wet and running sand, it was decided to drive 12 in. by 12 in. section reinforced concrete piles, 25 ft. long, down to a bed of hard clay, found at an average depth of 20 ft. below the towpath level. These provided adequate foundation for the reinforced concrete slabs, walls, and buttresses forming the abutments.

On the east abutment and between the face row of king piles (mentioned above), sheet piles, 6 in. thick, were driven to fulfil the purpose of a retaining wall, the west side being protected from the wash of the water in the canal by the towpath. In each abutment the heads of the piles are connected by horizontal beams both longitudinally and transversely at about 12 in. above water level. These are built in with an 8 in. thick foundation slab, 10 ft. wide from front to back. On the extreme edges (except back) of these slabs are built the 6 in. abutment face and wing walls, the latter being moulded in the shape of pilasters, while at the back of the former and immediately over each transverse row of piles were built buttresses 7 in. thick, the whole being of reinforced concrete and forming a very light but strong abutment for resisting the outward thrust of the arch and for supporting the weight of the super-structure.

The arch ribs, with a clear span of 26 ft. and a rise of 3 ft. 3 in. and a thickness of 6 in. at the crown, provide accommodation for the 20 ft. channel of the canal and a 6 ft. towing-path, the headway at the crown of the arch from water level being 10 ft. 5 in.

Fig. 4 is a transverse section through the crown of the bridge, by which it will be

Fig. 5.

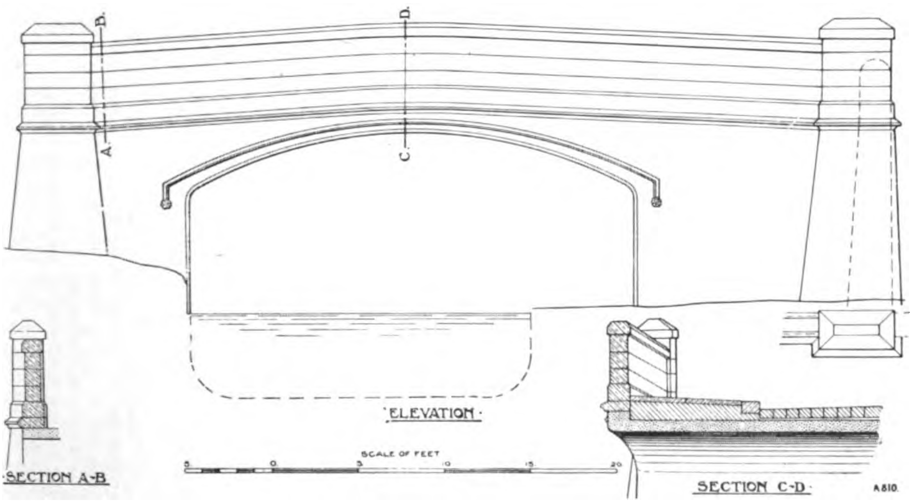


Fig. 2.

Fig. 3.

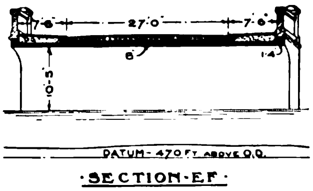


Fig. 4.

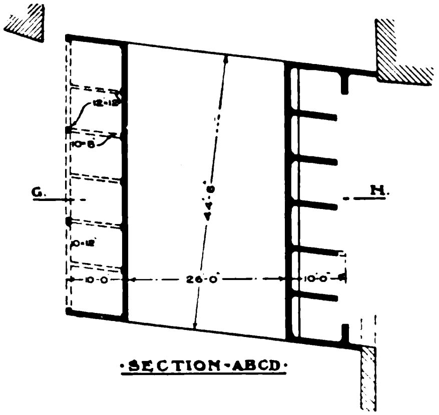
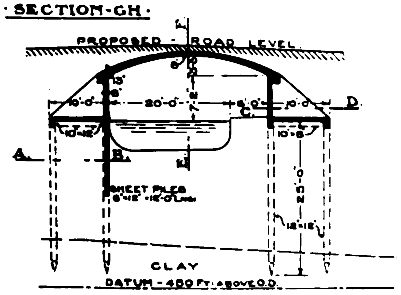


Fig. 6.



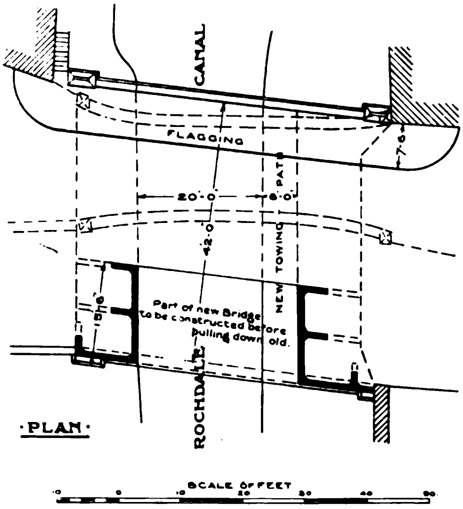
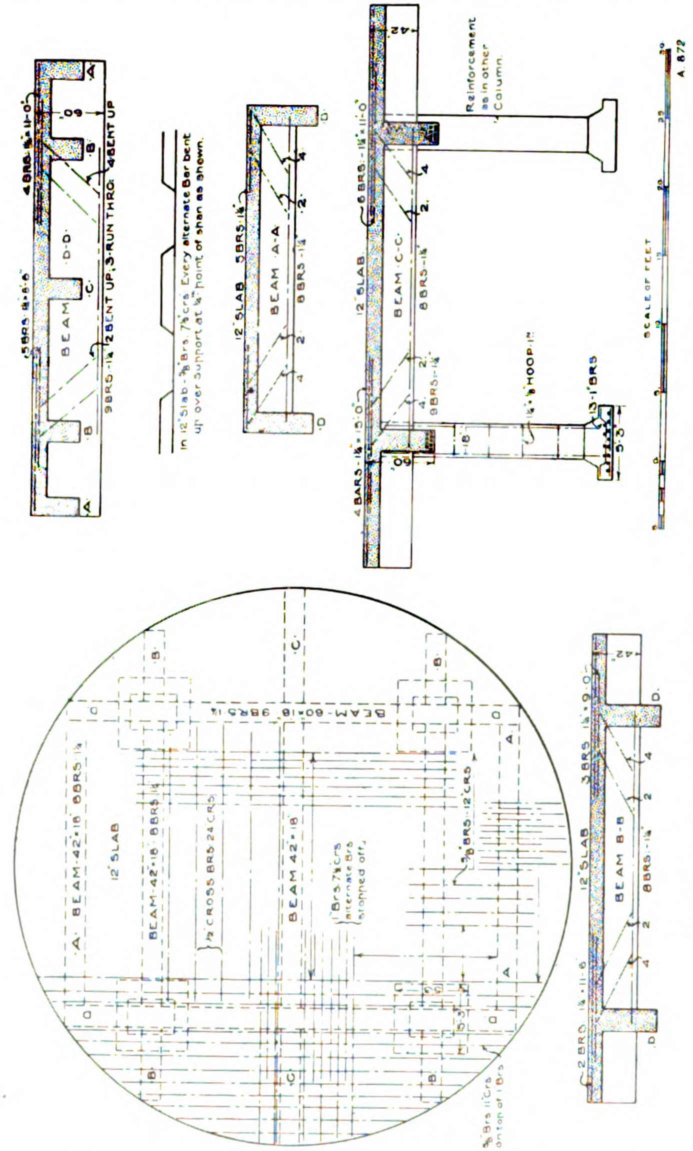


Fig. 7. Reinforced Concrete Bridge at Rochdale. Fig 1.

seen that between the parapets the accommodation for traffic includes two 7 ft. 6 in. footwalks and a 27 ft. roadway, the former being covered with 3 in. flagging, under which the water and gas mains are laid, while the latter is paved with granite setts, laid in about 1½ in. to 2 in. of fine sand, immediately under which a layer of bitumen sheeting lays directly on the top of the concrete surface. *Fig.* 5 is an elevation of the finished structure, showing the masonry caps to the reinforced concrete pilasters.


BEAM D-D
9BRS-1¼" 2 BENT UP, 3 RUN THRO. 4 BENT UP
In 12" Slab ⅜" Brs. 7½" crs. Every alternate Bar bent up over Support at ¼ point of span as shown.
12" SLAB 5BRS 1¼"
BEAM A-A
8BRS-1¼"
12" SLAB
BEAM C-C
8BRS-1¼"
Reinforcement as in other Column.
¼" HOOP
13-1" BRS
SCALE OF FEET
A 872
BEAM-60×18 9BRS 1¼
BEAM-42×18 8BRS 1¼
12" SLAB
½" CROSS BRS 24 CRS
BEAM 42×18
⅜" BRS 12 CRS
⅜" Brs 7½ Crs alternate Brs stopped off
BEAM B-B
12" SLAB 3BRS 1¼"

REINFORCED CONCRETE OIL TANK TABLE FOR THE SOUTH SHIELDS GAS COMPANY.

This table has been erected by the British Concrete Steel Co. of Newcastle-on-Tyne.

The top slab is designed to carry the heavy load of 13 cwts. per sq. ft. The reason the foundations were carried so deep was because a layer of running sand overlying rock was cut about 14 ft. below the surface, and consequently it was necessary to carry the foundations through it on to the solid rock below.

The drawings speak for themselves, but we may mention that the reinforcement consisted entirely of "Indented" bars.

The remainder of the exterior is in reinforced concrete with a facing of cement mortar and granite chippings, which is also applied to the introdos of the arch.

The construction work was by the Yorkshire Hennebique Contracting Co., of Leeds, and the designers of the reinforced concrete work were Messrs. Mouchel & Partners, Ltd.

REINFORCED CONCRETE FACTORY AT WARRINGTON.

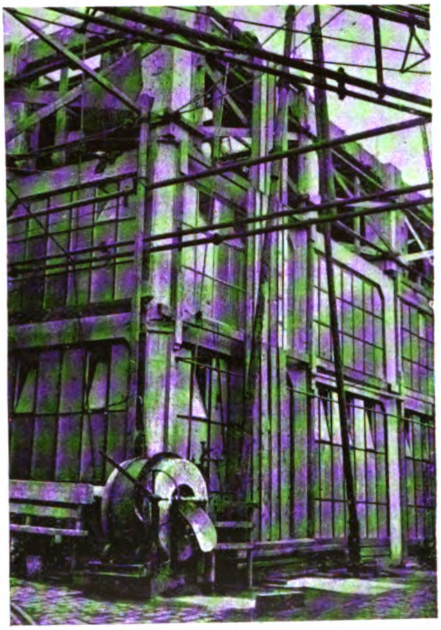
We present a view of the corner of a new reinforced concrete factory, built at Warrington by the Erasmic Company, Ltd.

It was imperative to have occupation of a portion of the building as early as possible. To meet this, the two storeys shown on the photograph were finished and occupied, whilst the three upper floors were in progress of being built.

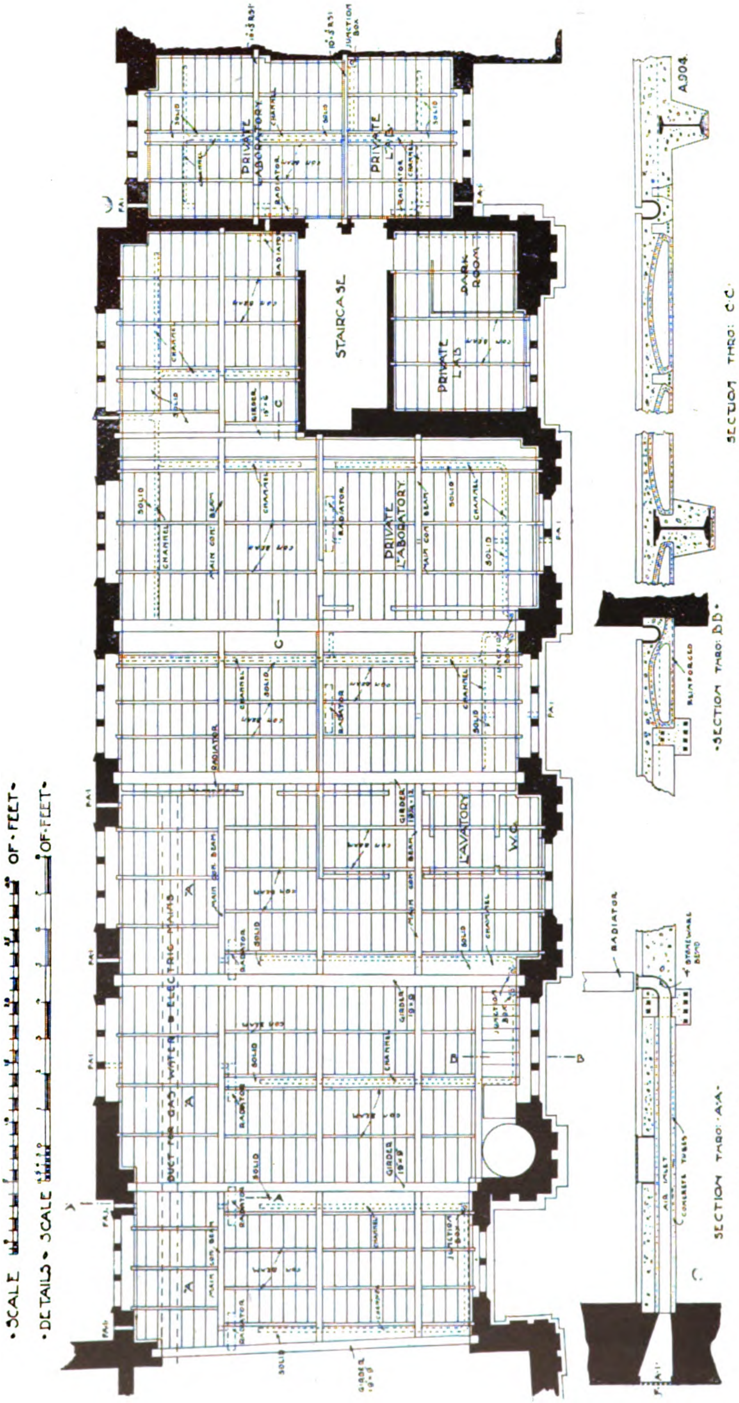
The view of the interior of the ground floor shows the machinery installed.

It is a good example of what can be done with this system of building, for it was designed by the firm's own staff, as their first experience with reinforced concrete, and carried out by them with direct labour.

The system used under license was that of "The British Reinforced Concrete Engineering Co.," of Manchester, and although it was rather early after building to load it so heavily, and with high-speed machinery, there is an absence of vibration and no cracks have appeared in any part of the work.



Reinforced Concrete Factory for the Erasmic Co., Ltd., Warrington.



HOLLOW REINFORCED CONCRETE FLOOR, CONSTRUCTED WITHOUT CENTERING, AT THE MEDICAL SCHOOL, CAMBRIDGE.

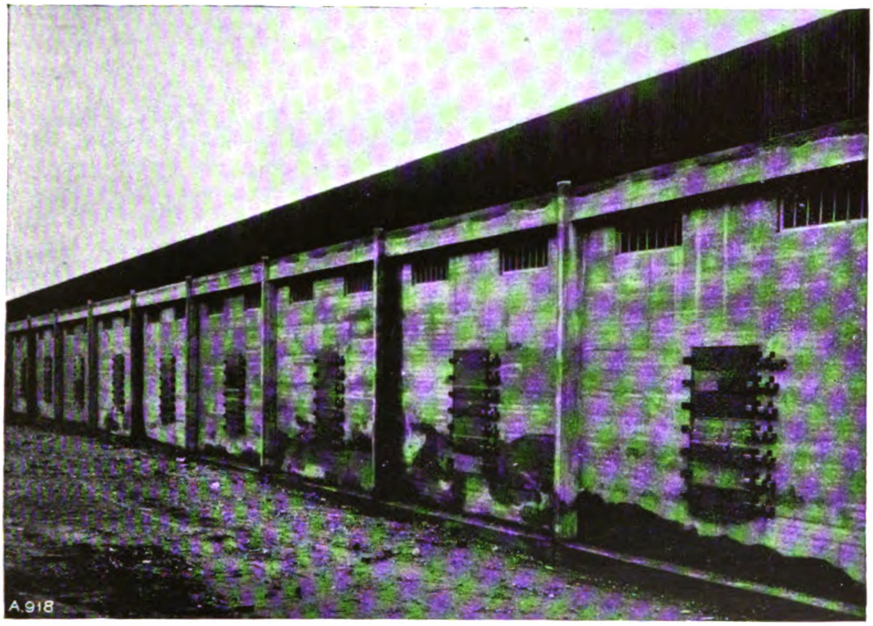
HOLLOW REINFORCED CONCRETE FLOOR AT CAMBRIDGE.

Much has been written of late relating to hollow floors, and we are publishing an example of such a floor as applied at the Medical School at Cambridge, by the United Kingdom Flooring Co., Ltd. The plan shows the floor construction of an extension to the Chemical Laboratory on the second floor level, with detailed sections showing how the ducts supplying air to the radiators are able to cross the floor channels for electric lighting and other pipes, and for carrying away the wastes from the numerous sinks; in other words, overcoming difficulties of a peculiar character which from time to time have to be surmounted.

The architects were Messrs. J. J. Stevenson and H. Redfern.

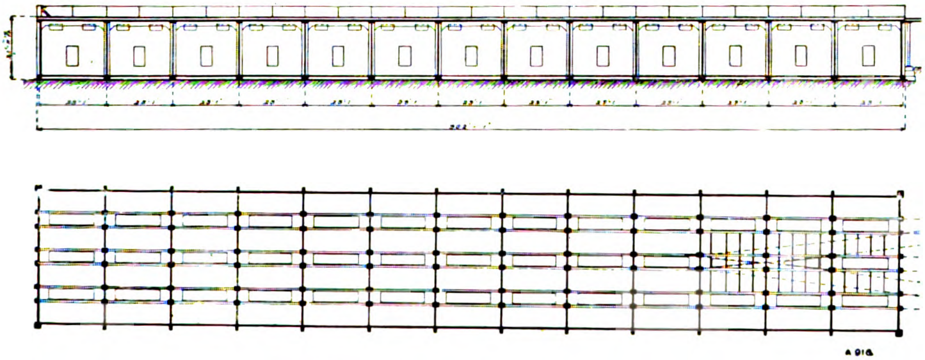
REINFORCED CONCRETE ORE BINS AT SEATON CAREW, COUNTY DURHAM.

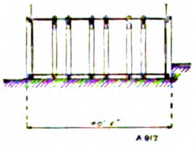
These Ore Bins were erected for the Central Zinc Co., Ltd., on the Coignet System, by Messrs. Watt Bros., of West Hartlepool. They are calculated to support three railway lines over which heavy engines weighing 60 tons, and loaded wagons, weighing 30 tons, are running, and are divided into 13 compartments.



The length of the bins is approximately 300 ft. The foundations are calculated to spread on the ground 1 ton per sq. ft. The side panels are only 4 in. thick. The decking is inclined in such a manner as to allow the rain water to run into the side channels.

A noticeable feature is the small height of the way beams, which measure 16 in. by 10 in. for a span of about 21 ft.





Reinforced Concrete Ore Bins at Durham

MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

The Brooklands Motor Track Bridge and Recent Litigation.—As there has been a considerable amount of misapprehension as to the case of Yorkshire Hennebique Contracting Co., Ltd., *v.* Locke-King, in which the defendant's pleadings indicated that he considered he had cause for complaint as to workmanship, we think it is fair, not only to the contractors, but also in the interests of reinforced concrete in a wider sense, to present a verbatim report of the remarks by counsel on either side when the settlement in this case was arrived at.

Counsels' remarks speak for themselves, and should, once and for all, put an end to the gossip as to the question of the stability or workmanship of the particular bridge or structure, which was illustrated in our issues Nos. 3 and 4 of Vol. II.

We take the opportunity of mentioning that before the settlement was arranged at the West Riding Assizes, which were held in the Leeds Town Hall, evidence was given in the interests of the plaintiffs by Mr. Stuart de Vesian, M.Inst.C.E.; Mr. Foxlee, M.Inst.C.E.; Mr. C. S. Meik, M.Inst.C.E., of Westminster, and others, and the evidence was mainly to the effect that the bridge was sound and that no defective workmanship could be found.

The contract price for the bridge was £4,666, of which £2,000 had been paid on account. The Yorkshire Company claimed the balance of £2,666, and the claim was settled by the reduction of £350 from that claim on a question of date of completion and not on the question of stability.

Counsels' remarks were as follows:—

MR. J. A. SIMON (representing the defendant): "My Lord, as you have seen, I have been speaking to my learned friend, and my client on my advice has agreed, as the result of a consultation between both sides, that this case should be brought to a conclusion by consent. It has been obvious, of course, from the beginning that something must be paid of this balance, and the real question, therefore, is how much should be subtracted, if anything, from the amount claimed in view of the expense to which Mr. Locke-King was put subsequent to the construction of the bridge from whatever cause owing to this wing wall failing. I have heard the evidence of the experts who were called yesterday, and their evidence quite satisfies my client that the bridge he has got is a perfectly good bridge. He is satisfied with the design of the bridge. Possibly some criticisms might have been made if we had gone right on to the end on small points of detail and so on, but the bridge is a bridge he is satisfied with. He desires me to say that he considers he has got a good bargain in getting the bridge. That being so, we have put our heads together. My learned friend realises, I know, that my clients have been put to extra expense in getting their bridge and their track in working order, and we have agreed that a sum of £350 is to be subtracted from the Contract claim, and I am prepared to consent to judgment for that diminished amount. That will, I hope, save your Lordship and the Jury from what would have been a much longer inquiry."

MR. TINDAL ATKINSON (for the plaintiffs): "My Lord, may I say this? My clients were most anxious that my learned friend should make a statement in open Court with regard to the character, design and workmanship of this bridge. That having been done, the way was smoothed at once for our coming to some sort of terms upon which this very costly action might be settled. Taking the view that my learned friend has indicated, my clients think that inasmuch as undoubtedly there was some delay in the completion of this Contract involving, I think, some four weeks beyond the time which they had stated to be the time within which they believed they could do the work, and having regard to the fact that probably the defendant was put to some extra expense and inconvenience in that matter they have agreed to deduct the sum of £350 from the total amount of this claim, so that there will be by consent a Verdict for the plaintiffs on the claim for £2,316 and Judgment and a Verdict for the plaintiffs on the Counterclaim and Judgment, the plaintiffs undertaking not to issue execution; and then there are some further terms which I need not mention: but which will be included in the Judgment."

Visits to Portland Cement Works.—An interesting series of visits has been undertaken to the Swanscombe Works of the Associated Portland Cement Manufacturers (1900), Ltd., in the first instance by the Architectural Association, and secondly by the Society of Architects. In each case the members of the respective societies were received by the directors of the company and the staff, and had an opportunity of obtaining a thorough insight into the manufacture of Portland cement, as well as the process of testing adopted.

LECTURES AND PAPERS.

Paper on Reinforced Concrete in America.—The most notable lecture on reinforced concrete during the past two months was that of Mr. Ernest R. Matthews, F.R.S.Ed., on "The Use of Reinforced Concrete in Engineering and Architectural Construction," before the Society of Arts, in which he presented a very useful summary in a not too technical manner, intended for the public which the Society of Arts enjoys—*i.e.,* the lay public with technical or scientific leanings. Sir Alex. Binnie, M.Inst.C.E., presided as chairman of the meeting.

Mr. Matthews limited his lecture to American examples, why we do not know, but as such his paper will be useful for reference purposes, specially as it contains a valuable appendix in the form of the Reinforced Concrete Regulations of the City of Chicago.

A fundamental error in the remarks of the chairman, Sir Alex Binnie, was that the slow progress of reinforced concrete among municipalities was due to the fact that reinforced concrete was subject to patents; whereas, as a matter of fact, only a few features in reinforced concrete are subject to patents, and the comparatively slow progress made is not on account of them at all, but simply due to the attitude of the Local Government Board on the loan period question.

Similarly his argument that reinforced concrete should make greater progress in architecture than in engineering is entirely belied by the experience obtained in other countries where reinforced concrete has made great progress. It is essentially an auxiliary for the civil engineering side, and for building it is of primary importance in such erections as factories and warehouses where the civil engineer has control, rather than in the domestic and public buildings where the architect is in charge.

We do not wish to criticise Mr. Matthews' paper at length, but we cannot agree with him in generalising as to the fire resistance of reinforced concrete without a proviso as to aggregate and covering of metal. We would similarly state that we look upon combinations of reinforced concrete and terra-cotta as entirely unsuitable for fire-resisting construction. Such work may be non-combustible construction, but it is certainly among those to be least recommended for fire resistance, having regard to the fact that while concrete and steel have one factor of expansion, tile or terra-cotta have an entirely different one.

It is rather extraordinary in a discussion of this kind to hear so much of the word "ferro-concrete." The proper technical description is "reinforced concrete."

Valuable contributions to the discussion were those by Mr. Charles Colson, M.Inst.C.E., and Mr. C. S. Meik, M.Inst.C.E.

The Society of Arts and their able secretary, Sir H. Trueman Wood, have certainly again lived up to their reputation of keeping matters of current importance before their members by having arranged for the reading and discussion of this paper.

CATALOGUES.

Coignet System.—We have received an interesting 60 page quarto pamphlet from Mr. Edmond Coignet, of 20, Victoria Street, London, S.W., describing his principal works at home and abroad. The pamphlet is prefaced by a good technical description and illustrated by drawings and photographs.

Of the works in Great Britain the Bristol Tobacco Warehouse is of perhaps the most interest, while abroad a concert hall at Paris with cantilever galleries is probably of the most technical importance. Two excellent illustrations are also presented of Mr. Coignet's official fire test in this country, when the classification of "Fully Protective" (Class B.) was obtained on a four hours' test, the floor, etc., under test measuring 15 ft. by 22 ft. 3 in.

The Cubitt Concrete Construction Co. send us a very interesting catalogue, comprising some 40 pages of illustrations and matter, descriptive of works executed and the principles of supervision exercised by the Company. The technical memoranda of this publication is much above the average.

Of the many illustrations the two that are technically of the greatest interest, being out of the common, are the curved roofs of Messrs. Whitbread's Brewery in Chiswell Street, E.C., and the "saw-cut" roof of the Acton Printing Works for Messrs. Roder, where the roof girders have a span of 57 ft.

It would appear that Messrs. Cubitt advocate the use of ordinary round rods for floor slabs, and such rods also vertically and hooped horizontally for columns, and that they use the Trussed Concrete Steel Co.'s bars for beams and girders.

RECENT CONTRACTS.

Messrs. W. Cubitt & Co.—Pile and reinforced concrete foundations at St. Edmund's Presbytery, Millwall, E.; foundations under machinery, Savoy Hotel; columns, girders and floors for a factory at Penarth; a racquet court for the Marquis of Bristol at Ickworth House, Suffolk; and patent reinforced concrete slabs for Oakbank Wharf, Southampton, comprise some of the work taken in hand by Messrs. Cubitt & Co.

Messrs. Richard Johnson, Clapham & Morris, Ltd.— From the list of works in which "Wire Lattice" has been used, we would mention instances on the London, Brighton & South Coast Railway Co.'s line for foundations for station buildings and bridges; as also cases of floors, roofs, walls, etc., for buildings for the Commissioners of H.M. Prisons. It has been used on dome work on the Stockport Town Hall; in floors for the Earlestown Library, and factory roofs for Messrs. Egleton & Sons. Abroad are floors and roofs for the Commonwealth Travellers' Association Building at Sydney; for the Transvaal University College at Johannesburg; and for the Royal Medical College, Vizagapatam.

Messrs. Robert McAlpine & Sons (Glasgow and London) have secured the contract for the construction of a new dock for the North British Railway Co. at Methil, Fifeshire. The contract sum is approximately half a million, the time to be taken three and a half years, and the engineers are Messrs. Blyth & Westland. A second important contract secured by the same firm is that for a large factory at Kinlochleven, Argyllshire, for the British Aluminium Co., Ltd., to be constructed in reinforced concrete on the Coignet system. It is being built under the superintendence of Mr. W. Murray Morrison, technical adviser, and Mr. Alban Scott, architect to the Company. The estimated cost of the work will be nearly £100,000.

Messrs. Patent Indented Steel Bar Co., Ltd.—Among the numerous works in which "Indented" bars are being used are the Mavis Mill, Manchester; floors for warehouse, Cambridge; post office, Milford Haven; telephone office in the North of Scotland; grammar school at Ashbourne; dockyard works at Devonport; tank in Yorkshire; swimming baths, Sheffield; warehouses at Leeds, Manchester and Liverpool; church foundations at Ince; engine sheds at Grangemouth; military store at Colchester; and many reservoirs, floors, etc.

Messrs. D. G. Somerville & Co. have secured a contract on their own design for a large building in reinforced concrete for Messrs. McVitie & Price at the Franco-British Exhibition, also for all the constructional steelwork required for the late Lord Mayor's Crippled Children's Home at Alton, and the steel roofing for Holloway Sanatorium, Virginia Water.

Messrs. The Trussed Concrete Steel Co., Ltd.—Among buildings at home in which the "Kahn" bar is being used are the London & South Western Railway Orphanage; a landing stage at Fawley; the Carnegie Library at Georgetown; jetty for H.M. Admiralty at Portsmouth; rafts at Hull and Tilbury; banks at Whetstone and Hull; a motor garage at Southwark; a retort house at Barking, and several reservoirs and warehouse buildings.

Abroad the list includes a building containing 800 tons of bars at Shanghai; a fire station and a residence at Colombo; a block of offices at Calcutta, and a reservoir in Sydney.

Weber Concrete Construction Co., Ltd.—This Company inform us they are executing two further chimneys in reinforced concrete for the Associated Portland Cement Manufacturers (1900), Ltd., at their Swanscombe works; and some reinforced concrete coal hoppers have been started by them at Croydon for the Corporation.

CHANGE OF ADDRESS.

Messrs. Stuart's Granolithic Co., Ltd., have opened City offices at No. 4, Fenchurch Street, E.C. The offices at their works, Millwall, E., will still be continued.

Messrs. The Considere Construction Co., Ltd., have moved to 5, Victoria Street, Westminster.

DEMONSTRATIONS.

The United Kingdom Fireproofing Co., Ltd. — An experimental load test was carried out last month by this firm, the floor having a span of 24 ft., and some interesting results were obtained. We propose to refer fully to the test on another occasion when dealing with the system of floor construction adopted by the makers on this occasion.

CONCRETE AND CONSTRUCTIONAL ENGINEERING

Volume III. No. 3. JULY, 1908.

EDITORIAL NOTES.

THE VIENNA INTERNATIONAL CONGRESS OF ARCHITECTS.

It is pleasing to be able to report that at the Vienna Congress of Architects the sectional meeting which enjoyed attention in the highest degree was that devoted to reinforced concrete, and the resolution passed upon that occasion, which calls upon Governments and others concerned to publish reports on all building accidents, should do much to prove how few and far between such accidents as have occurred with reinforced concrete structures are, in comparison with the general accidents on building and civil engineering works.

We have pointed out before how some slight building accident with reinforced concrete, involving the loss of a few hundred pounds, and perhaps no injury to life or limb, receives more attention in the daily Press than some great civil engineering disaster with steelwork, such as the collapse of the Quebec bridge, with its loss of half a million sterling and some eighty lives.

Occasional accidents on civil engineering works and in buildings of ordinary construction have long been accepted as a matter of course, and have been found, as a rule, to be due to the exigencies of rapid work or the carelessness of individuals; but reinforced concrete, being a new form of material, appears to invite the attention of the sensational journalist as well as the more mature pressman, and the result is that molehills are made into mountains, and grossly exaggerated reports prevail.

When the true facts of all structural accidents are some day published by different Governments as desired by the Congress, the rareness of reinforced concrete failures will be soon seen, and thus the sooner the information is officially published the better.

We believe the Home Office already has powers to obtain and issue such returns, and it is to be hoped that the resolution will have the attention of that department as far as Great Britain is concerned.

THE MILAN COLLAPSE.

The non-completion of the official inquiry into the collapse of a reinforced concrete building at Milan precludes our dealing with this accident as we would like, but we believe we are at liberty to plainly state that this regrettable collapse and loss of life was due solely to extraordinary negligence, and no principle of design is affected by the accident.

It is most regrettable that proper precautions should not have been taken during the testing operations to see that no one was working below the floor under test, and that no effort was made to place those who had the conduct of the test in places of vantage where they would not have been affected by an accident.

Testing operations are necessary and advisable in connection with every kind of building construction, and not least in connection with reinforced concrete floors and roofs.

It is during such tests that any inherent weakness should be shown; but it would almost seem on this occasion that risks were being run which in no way accord with the object of any such tests, and if the Milan disaster teaches anything, it is that greater care must be taken during testing operations, that loads should be preferably applied with the aid of cranes or "travellers" having their bearing points in suitable positions, instead of in the haphazard way we all too frequently see—*i.e.*, by gangs of men carrying loads.

We are fully aware that systematic loading is more timestaking than haphazard loading, and we are also aware that to stop workmen working on a building during the time of a loading test means delay, but surely the primary object of testing is to see to the safety of the structure for the use of human beings when in occupation, and no such test should be applied in such a hazardous manner that the lives of people working around and below the object under test should be at stake.

The Milan episode only teaches us to avoid risks when testing. As Mr. Harcourt (the First Commissioner of Works), in a reply at the House of Commons, rightly remarked, there was nothing in the Milan accident to prevent his using the best systems of reinforced concrete in buildings.

REGULATIONS FOR REINFORCED CONCRETE AT HOME AND ABROAD.

On another page we publish from the pen of Mr. Charles F. Marsh, M.Inst.C.E., a most valuable summary of the rules, regulations, and recommendations for the use of reinforced concrete as published in various countries. In the tabulated form in which the particulars are presented, the different points at issue can be compared at a glance.

Speaking generally, the various forms of rules, regulations, or recommendations show how most countries are now establishing municipal or Government rules regulating the design and erection of reinforced concrete structures, and have thereby admitted that it is a suitable and proper material for use in the construction of buildings and other works. England alone amongst the great nations remains without municipal or Government regulations, while our Local Government Board still persists in adopting an attitude which can only be considered as antagonistic to its employment.

The study of the table also shows that authorities insist, and rightly so, on great care in the selection of materials and in the erection and removal of the necessary falsework, on the exact placing of the reinforcement and its retention in place during the placing of the concrete, on the proper protection of the metal by sufficient covering of concrete, and on the intelligent design of structures by formulæ based on true principles, account being taken of the elastic behaviour of the two materials.

The later rules deal with hooped compression members, and by the higher resistances allowed for pieces constructed in this manner appear to encourage this method of reinforcement.

In most of the existing regulations no direct ruling is given as to the thicknesses of walls when constructed of reinforced concrete, but it is to be hoped that any regulations to be issued in this country will include this most essential feature.

THE LOCAL GOVERNMENT BOARD AND REINFORCED CONCRETE.

MR. JOHN BURNS, in reply to a question asked in the House of Commons, has again indicated that in his opinion there has not been sufficient experience in connection with the subject of reinforced concrete to enable him to arrive at a definite conclusion with regard to the economy and efficiency of buildings constructed of that material, and that he is still not satisfied that the period allowed for the repayment of loans (*generally only fifteen years*) for work so constructed can be properly extended.

In giving this reply Mr. Burns stated that he had been advised that it was doubtful whether reinforced concrete was a suitable material for structural works under all conditions, and that there was need for caution in dealing with it. He further pointed out that examples had been brought to his notice of failures of works constructed of this material.

It would be a mere matter of repetition on our part to reiterate our views on the extraordinary policy of the Local Government Board's officials in advising their chief in such a manner that he is practically compelled to give a reply of this description. As we have stated before, the anomaly of according timber roofs and floors a longer loan period than reinforced concrete is almost painful. The absurd position created by the Local Government Board's attitude towards the local authorities at a time when the three great spending departments of the Government are erecting notable works in reinforced concrete would indeed be laughable were it not of such serious economic import.

We think, however, that the time has come when Mr. Burns should take independent opinion on the subject instead of being guided by what are, obviously, the prejudices of some specific officer or officers in his department.

Such independent opinion might, perhaps, take the form of a small committee on which some of the officers of his own department, some from the great spending departments, such as H.M. Office of Works, the War Office, and the Admiralty, together with the representatives of the various technical institutions directly or indirectly concerned, should have seats.

We fully sympathise with Mr. Burns in his position. He is scarcely able to even take common-sense action in a matter of this kind when he is strongly advised by his staff that it would be wrong to do so.

But such an *impasse* has from time to time occurred in other departments of public life, and we feel sure that the President of the Local Government Board is a man of sufficient strength to obtain additional advice in circumstances such as those presented rather than allow the ridiculous *status quo* to remain indefinitely.

No one would in the least belittle a change in the opinions he has expressed on behalf of his department should he find that independent advice did not accord with that of the permanent officials who have had his ear in this matter till now.

THE CONCRETE INSTITUTE.

IT is with pleasure that we observe the formation of the Concrete Institute has been so well received, not only by the daily Press, but by our technical contemporaries, more closely associated with other forms of construction than ourselves.

There appears to be a consensus of opinion that the need for this Institute was a real one, and that it fills a want, owing to the not-too-friendly attention accorded the subject of concrete and reinforced concrete by some of the senior engineering societies.

Those who are connected with the subject will now have an opportunity of discussing points of difference, undertaking research and furthering their aims on mutual and independent ground.

When our last issue appeared, the Concrete Institute had just been founded with 100 founders, but the members and subscribers already nearly total 200 to-day.

Those interested in the subject will do well to obtain information as to the objects and constitution of the Institute, which enjoys the able Presidency of the Earl of Plymouth, late First Commissioner of Works, and has as vice-presidents Sir Henry Tanner, I.S.O., F.R.I.B.A.; Sir William Preece, K.C.B., F.R.S., and Sir William Mather, LL.D., M.Inst.C.E.

The Hon. Secretary is Mr. A. E. Collins, M.Inst.C.E., City Engineer of Norwich, and the offices are at No. 1 Waterloo Place, London, S.W.

The annual subscription for members is a guinea, but with a so rapidly increasing membership an entrance fee may be shortly determined on for members joining after the first 500 have been enrolled.

A MANUAL OF REINFORCED CONCRETE.

THE issue of a "Manual of Reinforced Concrete Construction" in pocket-book form is a matter of sufficient importance to be dealt with editorially in these columns, for we consider it an excellent sign of the advance made in this country in the application of reinforced concrete that both authors and publisher alike have found it expedient to produce a publication of this description.

The authors are Mr. Charles F. Marsh, M.Inst.C.E., and Mr. William Dunn, F.R.I.B.A., whose writings on reinforced concrete, and research work in connection with that subject are well known, and whose authorship suffices as a recommendation for the Manual.

The Manual has been published by Messrs. Archibald Constable & Co., who also published Mr. Marsh's pioneer work on the subject some years back.

It is not our intention to comment upon the Manual in detail; we would only in general terms congratulate the authors, but we think that in the second edition some of the matter might be still further condensed, and the tabulated system of presenting information still further developed with a view of reducing the number of pages. We also think that marginal notes would facilitate reference.

There is one criticism, however, which we think we ought to make. The authors speak of terra-cotta as an excellent fire-resisting material when simple in design, but go on to say that if applied to floors it must be in such a form as to resist also the stresses set up by unequal heating and the sudden application of water. Surely it would have been better in place of praising with an admonitory caution to have plainly condemned terra-cotta as commercially used—viz., dense terra-cotta with thin webs. Even concrete or reinforced concrete of poor quality has more advantages from a fire point of view than terra-cotta.

The supplement to the Manual is devoted to hollow blocks, the text, however, being mainly based on American experience.

SAFETY OF LIFE IN MINES.

At the International Life-Saving Congress, held at Frankfort last month, the question of safety and life-saving in mines was accorded exceptional attention; and, whilst fully agreeing and sympathising with the efforts being made to perfect the rescue work in case of fire or accident in mines, we think we should here specially call attention to the advantages of reducing the amount of inflammable timber in mines generally.

Pit wood has many disadvantages on the count of insufficient strength and expense in maintenance, but not least among these is its inflammability and the nature of the smoke and noxious gases thrown off by this type of wood when burning.

As we have shown in several articles, reinforced concrete is not only a useful substitute for timber in mines, but its application is economically sound for many purposes in mines, and its advantages from the point of view of safety in every direction enormous. Mine owners and mining engineers in this country should certainly study the question of introducing reinforced concrete into mines, and our public departments concerned would do well to encourage its use. The authorities should even make the use of non-combustible materials compulsory in certain positions and in certain classes of dangerous mines.

The International Life-Saving Congress was influentially attended from Great Britain, and we think some of the delegates should give this question of non-combustible materials and the use of concrete in mines their attention. The Home Office was represented by Mr. Henry H. Cunynghame, C.B., the War Office by Lieut.-Colonel Macpherson, C.M.G., the Foreign Office by Sir F. Oppenheimer, the British Fire Prevention Committee by Mr. Edwin O. Sachs, F.R.S.Ed., the Ambulance interests by Sir John Furley, C.B., LL.D., Lieut.-Colonel Barnes, and Dr. Osborn, F.R.C.S., while the Mining Association was represented by Mr. W. E. Garforth. The matter is particularly within the purview of the first and last named delegates as far as Great Britain is concerned, but the officers interested in India and the Colonies generally, especially Western Australia, would do well to consider the subject.

BELGIAN PORTLAND CEMENT AND GOVERNMENT CONTRACTS.

Under Memoranda we publish a question and reply in the House of Commons on the subject of the use of unreliable Portland cement at the Post Office at Kingston-on-Thames.

The risk of utilising foreign natural cements instead of the artificial Portland cement, for which this country has a reputation throughout the civilised world, has on several occasions been the subject of comment in this journal.

We feel sure it only requires a reminder to those responsible for the issue of specifications in our Government departments to attain our desire of seeing them brought up to date, by inserting the words that all cement used in Government work must be "*best artificial Portland cement in accordance with the requirements of the British Standard Specification.*" If our Government departments also worked on the principles of patriotism, which are to be found in the Government departments of the Great Powers of Central Europe, the word "*British*" would also be inserted before the word "*artificial,*" but we are afraid this is too much to expect, especially if we consider the regrettable amount of foreign material which has been of late notoriously applied in some of our War Office structures, such as the buildings on the Mill Bank site.

To, however, insert the words "best artificial Portland cement in accordance with the requirements of the British Standard Specification" would not affect any question of Imperial policy, but simply act as a safeguard for the officials concerned, and thus there can be no objection to their insertion in the specification for every Government building of the future.

THE LATE MR. L. G. MOUCHEL.

It is with great regret that we record in these columns the death of Mr. L. G. Mouchel, who for several years represented M. Hennebique, of Paris, in this country, and both in his capacity as representative of that well-known firm and as a civil engineer of high inventive faculties, did much to introduce and later on to develop reinforced concrete as we know it to-day.

Mr. Mouchel, by dint of industry, his power of taking pains in matters of detail, his extraordinary energy, and those attributes which overcome opposition and make a leader of men, achieved results in this country which are of the greatest credit to him and all associated with him. Handicapped by not being an Englishman, and thus by certain linguistic difficulties, and also by the fact that he only took up civil engineering at a somewhat late period of his life, further encountering prejudices against reinforced concrete and a conservatism that did little credit to our engineering profession, he nevertheless, by sheer pertinacity and the manner in which he inspired confidence, obtained the ear of professional men of influence who adopted the system of construction he represented, and arranged with contractors of the highest position to become licensees for execution of work that was entirely new to them.

In organisation, in his arrangements of contracts, and in what might be termed his "intelligence" department, he probably stood unrivalled; and if this journal has occasionally differed as to the means he adopted to attain desired ends, it has always respected his singularity of purpose and the success he attained.

His death is a loss to the development of constructional engineering in this country, but we feel assured that his colleagues of the firm of Mouchel & Partners, Ltd., will successfully continue the work of which he was such an able pioneer, and our sympathy and best wishes are with them on this sad occasion.

The Late Mr. L. G. Mouchel.

A SUMMARY OF THE RULES, REGULATIONS AND RECOMMENDATIONS FOR THE USE OF REINFORCED CONCRETE AS PUBLISHED IN VARIOUS COUNTRIES.

By CHARLES F. MARSH, M.Inst.C.E., M.I.Mech.E., M.Am.Soc.C.E.

Whilst many other countries and municipalities have Rules and Regulations governing the use of reinforced concrete, nothing of this description exists in this country, and the best available guide to be found for our purposes is the paper which takes the form of a Recommendation by the Joint Commission on Reinforced Concrete organised by the Royal Institute of British Architects last year.

It is, however, to be anticipated that the Local Authorities, and eventually the Local Government Board, must necessarily be framing by-laws on the subject of reinforced concrete, and we are thus presenting a summary of some of the principal Rules and Regulations on reinforced concrete issued in Europe and the United States.

It will be immediately seen that a considerable difference of opinion still exists as to the essentials in different countries, but this guide as issued should be of importance to public authorities framing rules, as also for architects and engineers carrying out work for large Corporations or public bodies.—ED.

INTRODUCTION.

THE increase of the use of reinforced concrete for all classes of structures where it can advantageously be employed has from time to time induced governments and municipalities to issue rules and regulations for the guidance and control of those who desire to adopt this material for constructional purposes.

In England at the present time we have no such rules and regulations, although some municipalities are contemplating their issue.

Although the recommendations recently issued by the Joint Committee on Reinforced Concrete, formed under the auspices of the Royal Institute of British Architects, have not the authority of Government Regulations, they are recognised as an authoritative pronouncement for the guidance of those who desire to erect structures of reinforced concrete in this country, and will no doubt be closely followed in the formulation of any rules and regulations which may be issued in the future.

In the following summary some of the more recent of the rules, regulations, and recommendations that have been issued up to the present time have been compared in a handy and compact form by tabulating their clauses under several leading headings.

Although this method may appear simple of accomplishment it has necessitated considerable rearrangement of the various publications to bring them into line, as the several portions are dealt with under different clauses by the various authorities, and it is hoped that no essential item has been omitted in consequence of this rearrangement of the clauses.

Perhaps the most noticeable fact brought out by the tabulation, is the total omission of any pronouncement on some of the headings by several of the authorities and the fullness of detail under the same headings by other bodies.

The completeness of the Recommendations of the Joint Committee instituted by the Royal Institute of British Architects, is well borne out by the tabulated comparison, and although other authorities have gone somewhat further in some particulars, these recommendations, undoubtedly, compare very favourably with the Government and Municipal rules and regulations in force in other countries.

SUBJECT	A (GT. BRITAIN) British Reinforced Concrete Committee:—Recommendations, 1907.	B (GERMANY) Prussian Government:—Regulations, 1904.	C (FRANCE) French Government:—Rules, 1907.	D (SWITZERLAND) Swiss Society of Engineers and Architects:—Recommendations, 1903.	E (AUSTRIA) Austrian Ministry of the Interior:—Rules, 1908.	F (U.S.A.) New York Municipality:—Regulations, 1905.
CEMENT.	To comply with requirements of specification of the British Engineering Standards Committee. Tests for constancy of volume, and setting time should be frequently made.	Must fulfil requirements of Prussian Specification. Certificates as to quality to contain statements as to constancy of volume, time of setting, fineness of grinding and tensile and compressive strength. To be delivered in the original packages.	Cement to be slow setting, except in cases where the concrete is poured into moulds.	Quality to be equal to Swiss standard.	Full specification given.	Only high grade Portland Cement to be used, must have tensile resistance of at least 300 lbs. per sq. in. after 1 day in air, and at least 500 lbs. per sq. in. after 1 day in air and 6 days in water, and at least 600 lbs. per sq. in. after 1 day in air and 27 days in water. Other tests for fineness, constancy of volume, &c., made in accordance with the standard methods prescribed by Committee of American Society of Civil Engineers may from time to time be prescribed by the Superintendent of Buildings.
SAND.	Hard grains of various sizes up to ¼in. mesh, of which at least 75% must pass ⅛in. mesh. Clean free from liqueous, organic, or earthy matter. Mortar of proposed sand, to be tested—washing does not always improve sand.	Only sharp sand, gravel, or other recognised material of suitable coarseness to be used.	*Nil*		Full specification given.	Sand must be clean, sharp grit sand, free from loam or dirt, and not finer than standard sample of the Bureau of Buildings.
STONE.	Gravel, hard stone or other suitable material, clean and angular, to pass ¾in. mesh, and retained on ¼in. mesh, as a rule but maximum size to be such as will pass between reinforcing bars or between bars and centering. Sand to be separated from stone before mixing. Limestone not to be used if structure to be fire-resisting.	*Nil*	*Nil*	To be clean and free from earthy matter. Gravel to be of such size as to pass between reinforcing bars, and between bars and falsework.	Full specification given.	Stone to be clean, broken trap rock or gravel, of a size to pass a ¾ in. ring. In case it is desired to use any other material, or other kind of stone samples must be submitted for approval of Superintendent of Buildings.
CONCRETE.	Tests to be made in important cases. Cement to be measured by weight, 1 cu. ft. of cement weighs 90lbs. Sufficient cement added	Compressive strength of concrete after 28 days must be stated in description, *vide* "General Regulations."	Amount of water must be sufficient for ensuring fluidity necessary for perfect embedding of reinforcements, and complete	Compressive strength of concrete to be at least 2,275 lbs. per sq. in. after 28 days in damp air. Mixture to be such that there	Concrete not to be weaker than 428 lbs. of cement per cu. yd. of sand and stone. Strengths of concretes of	Concrete to be in proportions of 1, 2, 4, or such proportion that resistance is not less than 2,000 lbs. per sq. in. after hardening

Subject	A (*Great Britain*)	B (*Germany*)	C (*France*)	D (*Switzerland*)	E (*Austria*)	F (*U.S.A.*)
Concrete— (*cont.*)	to sand to fill interstices. Sufficient mortar added to stone as will fill interstices + 10% **Machine mixing used where practicable. When hand mixing materials turned over until even colour on clean platform.** Amount of water depends on temperature and other factors. Seawater not to be used.	Cement as a rule to be measured by weight.	filling of voids in aggregate.	is at least 505 lbs. of cement per cu. sq. yd. of concrete in position. To be mixed in suitable machines, proper proportions carefully regulated. Strength determined in Federal Laboratory on cubes 6¼ × 6¼ × 6¼ in. or prisms 14⅛ × 4¾ × 4¾ in. Prisms will also be used to ascertain resistance to tension from bending tests.	various proportions are given.	for 28 days. Must be a "wet" mixture. Tests to be made under supervision of the Superintendent of Buildings.
REINFORCEMENT.	Ultimate strength not less than 60,000lbs. per sq. in. Elastic limit not less than 50% or more than 60% of ultimate strength. Elongation small round bars not less than 22% on a length of 8 diameters. Round bars over 1in. in diameter not less than 27% on a length of 4 diameters. Other sections as prescribed in British Standard Specification. Welding in general forbidden. In special cases welds to be at points of least stress.	*Nil*	*Nil*	*Nil*	*Nil*	Steel to meet requirements of Section 21 of the Building Code.
ERECTION.	Reinforcements to be placed and kept in proper position. Apart from fire resisting the bars to be not nearer than 1in. from surface of beams, and ½in. from surface of floor slabs or other thin structures. Metal to be properly coated with cement. Layers of concrete before ramming not to exceed 3in. Recently laid concrete should be wetted before adding fresh layer. Hardened surfaces to be hacked up, swept clean and covered with cement grout before adding new concrete. No concreting to be carried on when temperature below 34° Fahr.	Reinforcement to be correctly placed. Concrete layers before ramming not to exceed 6in. Metal to be thoroughly coated with cement mortar. Concrete to be prepared only in such quantities as required for immediate use. It is to be put in place immediately after mixing and uniformly rammed. If plastic, ramming to be continued till water appears on surface. For ramming properly shaped stamps of appropriate weight must be used. Main walls to be raised simultaneously through their whole length, and care taken to make good	Fixing in position of reinforcement to be of sufficient rigidity to resist shocks and loads during construction. Concrete, except when poured into moulds, to be rammed in layers suitable to size of aggregate and spacing of reinforcements, but never greater than 2 in. after ramming except when stones are used as aggregate. Reinforcements to be so spaced from each other and sides of moulds, that ramming may be perfect and the concrete be forced into contact with them. Thickness of concrete outside reinforcements never to be less than 0·6 to 0·8 in.	Reinforcements to be placed in exact positions shown on the drawings and their sizes must be carefully checked. If metal is rusty it must be cleaned before putting in place. Work of erection only to be entrusted to those thoroughly conversant with this method of construction. Only trustworthy foreman having experience in this class of work to be employed.	Minimum distance of reinforcements from side of moulds t be 0·4 in. Only skilled workmen and experienced foremen to be employed. Concrete of consistency of moist earth in layers not greater than 6 inches. Wet concrete in layers not exceeding 8 inches. Concrete not dropped from greater height than 6 feet. Reinforcements to be carefully placed and fixed, and well covered by the mortar of the concrete. Interruption of concreting only where concrete not exerting full allowable resistance. Hardened concrete to be roughened, cleaned and	Execution to be confined to workman under the control of a competent foreman or superintendent.

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Erection— *(cont.)*	All shaking or jarring to be avoided. Fresh work to be protected from frost and sun rays.	connection with adjoining cross walls. Layers completing a storey to be finished off level. Recently laid concrete to be wetted before more added. Hardened surfaces to be roughened, swept and wetted. In construction of walls and columns in buildings, the upper storey not to be commenced until that below has been approved. Concreting not to be carried on in frost unless precautions taken. After a frost work not to be recommenced without permission of authority. Until sufficiently hardened concrete to be protected from frost, premature drying, and from shaking or overloading. Time book to be kept. Days of frost entered with records of temperature.	Stopping of concreting to be avoided as much as possible, when it is necessary hardened concrete to be cleaned, roughened and watered before fresh concrete added. Concrete to be kept moist for 15 days after moulding. Work to be stopped in frosty weather unless efficaciously protected. If any part of work injured by a frost it must be cut out.		wetted with 1 to 1 neat cement grout before more added. Concrete not laid in frosty weather unless precautions taken. Concrete to be kept wet until sufficiently hardened Use of members moulded in advance not allowed without special permission Provision for protection against penetration of water.	
FIRE PRECAUTIONS.	No limestone to be used. Best materials for fire resistance :— (1) Coke breeze, cinders or slag. (2) Broken bricks. (3) Gravel or stone. Rigidly attached web members, loose stirrups, bent-up bars or other connection between metal and compression sides of beams or slabs are very desirable. Metal to be covered by concrete 1in. thick for floor slabs, 1½ to 2in. thick for other parts—all angles to be splayed or rounded. For highest fire resistance concrete should be covered with special fire resisting materials.	*Nil*	*Nil*	*Nil*	*Nil*	Approval withheld for buildings required to be fireproof unless satisfactory fire and water tests shall have been made under the supervision of the Bureau of Buildings. 4 hours fire test at 1700° Fahr. under load followed by water from steam fire engine.

Subject	A (Great Britain)	B (Germany)	C (France)	D (Switzerland)	E (Austria)	F (U.S.A.)
FALSE-WORK	To be rigid and unyielding during laying and ramming of concrete. To be easily removed without jarring concrete. Timber to be covered with limewash.	To possess sufficient resistance to bending and shaking during ramming, and to be so arranged so as to be removable without danger to the necessary supports remaining in place. All shaking to be avoided when removing falsework.	To be of sufficient rigidity to withstand without noticeable deflection loads and shocks occuring during construction and in removal of moulds, &c.	Care to be given to design and erection, so that it is capable of allowing rammings of concrete in thin layer without injury.	To be rigid and unyielding during laying and ramming concrete. To be removable without shock. Proper cambers to be provided. No appreciable loading until forms and supports are removed.	*Nil*
STRIKING CENTRES.	Depends on dimensions or thickness of structure, amount of water used in mixing, state of the weather during deposition and setting, and whether or not to be loaded directly after removal of centering. Casings for columns and sides of beams and bottoms of floor slabs not more than 4ft. span not to be removed under 8 days. Bottoms of beams or floor slabs of greater span than 4ft. to remain up at least 14 days. For large span arches centering not to be removed under 28 days. If frost occurs during setting of concrete period to be extended by time of duration of frost.	Casings for columns and centering for floors of 5ft. span or less may be removed not less than 3 days, and all other falsework not less than 14 days after moulding. Special care to be taken in removal if concrete is finished shortly before commencement of a frost. If frost occurs during setting of concrete, above periods are to be increased by the time of duration of the frost.	Moulds, &c., to be removed without shocks by purely static forces and only after the concrete has sufficient resistance to sustain without injury the stresses to which it will be subjected.	Before striking it must be ascertained that concrete is sufficiently set. Centering for slabs or beams not exceeding 10 ft. span not to be removed in less than 10 days after moulding. For beams of 10 to 20 ft. span and for columns, falsework to remain for 20 days nd for longer spans 30 days. In buildings with several floors, the removal of supports to begin on the top floor and proceed downwards. Before striking, report to be made stating if all parts of the work have been properly carried out.	Supporting parts not to be removed until concrete sufficiently hardened and never before four weeks after completion of ramming, but sides of forms after four days. If frost occurs during setting of concrete, period to be extended by time of duration of frost. Shocks to be avoided.	*Nil*
TESTING.	Test pieces of concrete in form of cubes not less than 4 in. on edge or cylinders, not less than 4 in. diameter, having length not less than diameter tested before designing important work and during erection. Average of not less than 4 cubes or cylinders for each test. Tests to be made 28 days after moulding. 1 : 2 : 4 concrete to have strength of not less than 2,400 lbs. per sq. in. Loading tests not to be made till 2 months after completion.	Testing blocks to be provided 8 in. or 12 in. wide, according to coarseness of aggregate. Portions of building in positions determined by building authority are to be exposed if desired so that mode of construction may be seen. Special tests may be made to determine hardness and strength. Test pieces may be cut out of finished building. If loading tests are considered necessary, they are to be carried out under	Conditions of tests and time that shall elapse before structures are brought into use must be inserted in contract, and also the maximum deflections as far as practicable. The time to elapse before use of structures must be 90 days for structures of primary importance, 45 days for ordinary constructions and 30 days for floors. Measurements to be taken during tests which are likely to be of scientific interest to engineers.	Test loads to be at least 50% greater than working loads allowed in calculations. Test loads not to be put on until 45 days have been allowed for setting. If possible deflections at different stages of loading to be noted.	Breaking tests of whole or part to be made on request. No test before expiration of six weeks after completion of ramming. Loading to be such that effect is same as dead load plus 1½ specified superimposed load. No cracks or permanent deformations. For breaking tests load to be gradually increased. Breaking load not to be less than 3½ times the total dead and superimposed load, less the weight of the member.	Test loads to be three times loads for which structure is designed. Tests to be made on any portion of the construction within a reasonable time after erection, as often as may be required by the Superintendent of Buildings. To show no sign of failure.

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Testing—(*cont.*)	Test load not to exceed 1½ times superimposed loading. Consideration to be given to adjoining parts of a structure in case of partial loading. No test load to be applied which would cause metal to be stressed more than ⅔ of its elastic limit.	instructions of representative of building authority. When a strip cut from a floor or decking is tested, the load shall be uniformly distributed and shall not exceed the weight of the strip and twice the working load. If strip is tested in situ, the above loading shall be increased by one-half.	Test loads on floors shall be the dead and superimposed loads acting over the whole area of the floor, or at least upon a complete panel. The loads to be left on for at least 24 hours, and deflection to cease after 15 hours.			
LOADING.	Weight of concrete to be taken as 150 lbs. per cu. ft. Weight of any covering to floors must be added to dead load. Superimposed load should be multiplied by 1½ for public halls, factories, workshops, &c., and by 2 for floors carrying machinery, roofs of vaults, underpassage ways, court-yards, &c. Columns in buildings supporting three or more floors. For supports of roof and top floor, the full load. For support of 1st floor below top add to foregoing 0·90 load on this floor. For support of 2nd floor below top, add to foregoing 0·80 load on this floor, and so on until for supports of 5th floor below top, and all other floors, add to the load calculated as above for the higher floors 0·50 load on the floor under consideration.	Weight of concrete shall be taken as 150 lbs. per cu. foot, unless different weight is determined definitely. Weight of any covering to floor must be added to dead load. For parts of structures subjected to considerable vibration or to greatly varying loads as floors of public halls, dancing rooms, factories, or workshops, superimposed load to be multiplied by 1½. For parts subjected to heavy shocks, as roofs of vaults, under passage ways or court yards, the superimposed load to be multiplied by 2.	The loads on roofs to be in accordance with Ministerial regulations of Feb. 17th, 1903, dealing with metallic roofs for railways, unless exceptions are justifiable. Floors and other parts of buildings, retaining walls, walls of reservoirs or conduits under pressure where affecting public safety, to be designed for maximum loads they may have to carry.	Weight of any covering, &c., to be added to dead load. In determining superimposed load allowance to be made for any shock or vibration it may produce.	*Nil*	*Nil*
BENDING MOMENTS, &c.	Span of beams or continuous floor slabs to be from centre to centre of supports. Span for slabs supported at	Span for beams to be free opening plus one support. Span of continuous decking to be distance from centre to centre of supports.	For freely supported or continuous beams usual values may be applied. For partially fixed ends the bending moment at	Most unfavourable disposition of loading to be allowed for. In continuous or encastre beams the bending mo-	Spans for freely supported and continuous beams to be from centre to centre of support. Beams extending over	Beams and girders to be considered as freely supported, no allowance to be made for continuous construction.

Subject	A (Great Britain)	B (Germany)	C (France)	D (Switzerland)	E (Austria)	F (U.S.A.)
Bending Moments (cont.)	ends clear span plus thickness of slab. Bending moments where l = span in feet and w load per lineal foot. Beam or slab freely supported $\frac{wl^2}{8}$ foot lbs. Continuous beams or slabs or those fixed at ends if reinforced near upper surface at supports. If continuity or fixing is absolute, $\frac{wl^2}{24}$ at centre of span and $-\frac{wl^2}{12}$ over supports, generally, in building construction, centre bending moment should not be less than $\frac{wl^2}{12}$ Bending moments over supports to correspond with bending moment at centre of span.	For freely supported decking the clear span plus the thickness of the decking. Bending moments and reactions to be determined by formulæ for freely supported or continuous beams according to mode of support and distribution of load. For continuous decking bending moment at centre of panel is to be taken as $\frac{4}{5}$ of that which would exist in a freely supported panel, unless the moments and reactions can be ascertained. Above rule holds good for beams, excepting that no end moment is to be taken into account unless special arrangements have been made to fix the ends.	centre of span for uniformly distributed load to be $\frac{wl^2}{10}$ If L and B are the spans of a rectangular slab the bending moment as for a beam of span B can be decreased by co-efficient $\frac{1}{1+2\frac{B^4}{L^4}}$ or span L the bending moment as for beam of span L with the co-efficient of reduction of $\frac{1}{1+2\frac{L^4}{B^4}}$	ments at centre of spans not to be less than $\frac{2}{3}$ the moments at the supports, due to the loading and amount of fixing and reinforcement over supports is to be provided. If amount of fixing cannot be determined, the moment at centre of span must not be less than 20% that for a freely supported beam and that at supports to be at least half of that at centre.	several supports must be computed as for continuous beams, incidental unfavourable loading being taken into account. Continuity not to be assumed as extending over more than three spans. Elastic deformation in supports of continuous beams to be taken into account. In beams the possibility of fixing moments at the supports must be provided for by suitable reinforcements. If L and B are spans of rectangular slab, and L is not more than one and a half B, slab being reinforced with equal area of metal both ways bending moment as for beam of span B can be decreased by co-efficient $\frac{L^4}{L^4+B^4}$	Slabs when continuous and provided with reinforcements at the top over the supports may be considered as continuous, but the bending moments at centre of span to be not less than $\frac{wl^2}{10}$ For continuous square slabs supported on four sides bending moment may be taken as $\frac{wl^2}{20}$
ALLOWABLE STRESSES	Concrete to be not weaker than 1 : 2 : 4 to have crushing strength of 2,400 to 3,000 lb. per sq. in. Co-efficient of elasticity concrete $E_c = 2{,}000{,}000$ lb. per sq. in. Ditto steel $E_s = 30{,}000{,}000$ lb. per sq. in. $\frac{E_s}{E_c} = 15$	$\frac{E_s}{E_c} = 15$	$\frac{E_s}{E_c} = 8$ to 15. Minimum when diameter of longitudinals $\frac{1}{10}$ least dimension of member, ties or transverse reinforcements spaced apart a distance equal to least dimension of member. Maximum when diameters of bars equal to $\frac{1}{30}$ least dimension of member and spacing of ties, &c. $\frac{1}{3}$ least dimension of member.	$\frac{E_s}{E_c} = 20$	Co-efficient elasticity of concrete in compression, 1,990,000 lb. per sq. in Co-efficient elasticity of steel in tension or compression, 29,850,000 lb. per sq. in. $\frac{E_s}{E_c} = 15$ Resistance of concrete in tension neglected in calculating strength.	$\frac{E_s}{E_c} = 12$
	Resistance of concrete in tension to be neglected. Concrete in beams, &c., 600 lb. per sq. in. Concrete in simple compression 500 lb. per sq. in. Concrete in shear 60 lb. per sq. in. Adhesion of concrete to metal 100 lb. per sq. in.	Resistance of concrete in tension neglected. Concrete in beams $\frac{1}{3}$ ultimate compressive resistance. Concrete in simple compression $\frac{1}{10}$ ultimate compressive resistance. Concrete in shear, 64 lb. per sq. in. or $\frac{1}{5}$ ultimate. Adhesion of concrete to steel same as in shear.	Resistance of concrete in tension taken into account for calculation of deformations but not resistance. Concrete in compression not to exceed 28% crushing strength of 8 in. cubes of plain concrete 90 days old. When hooped or when transverse or oblique reinforcement disposed to	Resistance of concrete in tension neglected. Concrete in compression 498 lb. per sq. in. Concrete in shear 56 lb. per sq. in.		Resistance of concrete in tension neglected. Concrete beams, &c., 500 lb. per sq. in. Concrete in simple compression 350 lb. per sq. in.

Weight of cement in lbs. to cubic yard of sand and stone	Proportions in Volume	Concrete Working Stresses lbs. per square inch: Bending or Eccentric Loading – Compression	Bending or Eccentric Loading – Tension	Simple Compression	Shearing	Adhesion
720	1 : 3	570	341	398	64	78
535	1 : 4	512	327	355	64	78
428	1 : 5	454	305	312	50	64

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Allowable Stresses— (*cont*)	Steel in tension, ultimate resistance not less than 60,000 lb. per sq. in. } 15,000 to 17,000 lb. per sq. in. Ends of bars in beams, &c., should be split open or bent at ends or other security provided against slipping. When stronger concrete used the resistance for beams to be taken at ¼ ultimate, and in simple compression ⅕ ultimate. When stronger steel used tensile resistance to be ½ that at elastic limit.	Steel on tension or compression not to exceed 17,000 lb. per sq. in. So far as possible reinforcements to be of such form that displacement relative to the concrete is prevented.	prevent swelling of concrete above resistance may be increased in proportion to volume of bars and their suitability of arrangement, but safe resistance to be never greater than 60% crushing strength. Concrete in shear and adhesion of concrete to steel 28% of crushing strength of concrete. Steel in tension and compression not more than ½ strength at elastic limit reduced to 40% for members such as slabs subjected to alternating stresses. For members subjected to stresses, varying within wide limits safe resistances to be reduced, but not more than 25%.	Steel in tension (in beams) 14,223 lb. per sq. in. Steel in tension (in slabs) 17,068 lb. per sq. in. Steel in compression 9,956 lb. per sq. in.	Soft Steel Tension, 13,500 Medium Steel ,, 14,200 Steel Shear ... ... 8,530 Stirrups or transverse connections must be provided in sufficient numbers. Ends of reinforcing bars must be so shaped to ensure security against slipping unless the surface of the bar is so formed as to resist displacement relative to the concrete. If any other proportions used for concrete safe resistance are to be calculated by rectilinear interpolation from the values for the weight of cement per cu. yd. of sand and stone as given above.	Concrete in shear 50 lb. per sq. in. Adhesion of concrete to steel 50 lb. per sq. in. Steel in tension 16,000 lb per sq. in. Steel in shear 10,000 lb. per sq. in. Not more than 10 times width of rib.
RULES FOR CALCULATION.	The deformation in a piece subjected to bending directly proportional to the distance from the neutral axis—*i.e.*, straight line stress—strain relation. Width of slab acting with T beam to be not more than ⅓ span or ¾ distance centre to centre of reinforced ribs, whichever is least. Shearing and adhesion stresses should be calculated and special provision made to resist these if necessary. Calculations given for eccentrically loaded columns and for long columns vertically loaded when the length exceeds 18 times least diameter. Calculations for long columns made by Gordon's formula with value for constant of 32,000.	Straight line stress—strain relation. Width of slab acting with T-beam to be not more than ⅓ span. Shearing and adhesion stresses to be calculated and special provision made to resist these if necessary For columns the possibility of eccentric loading is to be taken into account. Transverse connections in columns not to be further apart than 30 times diameter of rods. Calculations for flexure of columns to be made whenever height exceeds 18 times least diameter. Euler's formula to be used for calculating flexure of columns, a factor of safety of 5 being allowed when calculating for flexure of the reinforcements, no support being allowe from	Straight line stress-strain relation. Width of slab acting with T-beam to be not more than ⅓ span or ¾ distance centre to centre of reinforced ribs, whichever is least. Shearing and adhesion stresses to be calculated and special provision made to resist these if necessary. Columns calculated for eccentric loading. Calculations given for hooped columns. Calculations for flexure to be made for columns when height exceeds 20 times least diameter. Account to be taken of temperature and shrinkage stresses as well as loading if structure cannot expand and contract freely.	Straight line stress—strain relation. Shearing stresses to be calculated and if exceeded reinforcement to be introduced by bending up bars or otherwise to resist it. For columns any eccentric loading must be taken into consideration. The reinforcement is to be calculated to resist bending as if unsupported by concrete by Euler's formula with factor of safety of 4, half distance between the bindings being assumed as the unsupported length.	In pieces subject to flexure maximum tensile stress in concrete to be calculated on assumption of a modulus of elasticity of 796,000 lb. per sq. in. for concrete in tension. Shearing and adhesion stresses calculated, and special provision made to resist these if necessary. If deformed bars used adhesive resistance may be assumed as exceeding values given above by 10%. Column reinforcement calculated separately for flexure, ties not spaced farther apart than least diameter of column. Sectional area of metal in columns not less than 0·8% of total sectional area of column. If sectional area of metal exceeds 2% of total sectional area of column, the excesses be-	Straight line stress—strain relation. Width of slab acting with T-beam to be not more than ten times width of rib. Shearing and adhesion stresses to be calculated, and special provision made to resist these if necessary. Transverse connections in columns to be spaced apart at distance not greater than least diameter or side of column. Calculations for flexure to be made for columns when height exceeds 12 times least diameter or side.

Subject	*A (Great Britain)*	*B (Germany)*	*C (France)*	*D (Switzerland)*	*E (Austria)*	*F (U.S.A.*
Rules for Calculation—(cont).	In T-beams, when neutral axis falls below bottom of slab the resistance of the concrete in the rib is neglected. The thickness of slab for T-beams determined by stiffness required for floor in general, it is from $\frac{1}{12}$ to $\frac{1}{16}$ of the span.	concrete, and 10 when calculating for whole column. In T-beams when neutral axis falls below bottom of slab the resistance of the concrete in the rib is neglected.			yond 2% only be taken into account to extent of ½ its value. Eccentric loading of columns to be taken into account. Calculations for flexure made for columns when height exceeds 20 times least radius of gyration. Free length being that between fixed ends. Hooped column formulæ.	
GENERAL REGULATIONS.	*Nil*	Special examination of building authority to proceed erection of any building or portion of building. Application for permission for erection must be accompanied by drawings, statical calculations, and descriptions. Description must state origin and nature of materials to be used in concrete, and the proportions in which they are to be mixed. Application to be signed by building owner and the contractor charged with the erection.	Quality and proportions of concrete to be specified in the contract.	Designs prepared so that drawings and calculations show clearly general arrangements, allowed loads, calculations of strength, and details of parts. It is permissible to depart from the regulations if the variations are based on actual trial and upon the opinions of competent persons.	*Nil*	Complete and specifications must be filed with the superintendent of buildings showing all details of construction, size and position of reinforcing rods, stirrups, etc., and giving the composition of the concrete and size of aggregates.

METHODS OF CALCULATION.

As will have been observed from the preceding tables it has not been possible to bring the details of the several calculations into a tabular form, since it is very difficult to deal with more or less complicated formulæ in this manner, but the main principles on which the formulæ are based have been set out in the table.

Some of the rules and regulations do not include the methods of calculation; either omitting them altogether or setting them out in an explanatory circular accompanying the primary clauses.

This latter method has been adopted by the French Government, who have dealt very thoroughly with the subject of calculations and have set out fully the reasoning upon which the several formulæ are based, and the methods to be adopted in their employment. The French Government in their explanatory circular deal in considerable detail with hooped compression members, and are, with the Austrian Government, the only authorities appearing in the table, who make any allusion to this important application of reinforced concrete.

They say on this subject "the intelligent use of the metal, not only for longitudinal, but also for the transverse oblique reinforcements, is to be encouraged, in order that it may be able to assist the concrete to withstand the swelling action due to longitudinal pressures." They give the expression $1 + m'\frac{v'}{v}$ as a coefficient by which to multiply the safe crushing resistance of the concrete when the piece is hooped, V' being the volume of the transverse or oblique reinforcement, V the volume of the concrete corresponding to the same length of prison, and m' a coefficient varying with the degree of efficiency of the binding. With windings having a pitch of $\frac{3}{8}$ the least transverse dimension of the piece m' may be taken as 15. For a pitch of $\frac{1}{5}$ the above dimension m' becomes 32 for a safe resistance to crushing of 710 lb. per sq. in., while it has the same value with a pitch of $\frac{1}{8}$ the least transverse dimension of the piece for a safe resistance to crushing of 1,420 lb. per sq. in., but in any case the safe working direct pressure to be allowed must not exceed 60 per cent. of the strength of plain concrete of the proportions adopted at the age of 90 days.

By employing the above coefficient the safe resistance of the concrete in the hooped column is obtained, *i.e.*: if c is the safe resistance of plain concrete, then the safe resistance of the concrete in a hooped piece is $c(1+m'\frac{v'}{v})=c'$, and c' is used for insertion in the formula usually adopted for reinforced compression pieces, or $P=c'\left\{bd+(m-1)\,\omega\right\}$, where P is the safe load bd is the sectional area of the piece, m is the ratio of the coefficients of elasticity of the steel and concrete, or $\frac{Es}{Ec}$ and ω is the sectional area of the longitudinal reinforcements.

In other words the hooping is considered as increasing the crushing strength of the concrete due to the resistance it offers to the lateral swelling

The Austrian Government give the following methods of calculation for hooped compression pieces where A = the imaginary sectional area of the piece, A_c = the sectional area of the concrete, A_l = the sectional area of the longitudinal reinforcement, and A_h = the sectional area of an imaginary longitudinal, the weight of which is equal to that of the hooping reinforcement, both weights being reckoned per unit length of the piece.

$$A=A_c+15A_l+30A_h.$$

If A is more than $1{\cdot}4\,(A_c+15A_e)$ or $1{\cdot}9A_0$, then A must only be taken as equal to the smaller of these two values.

Under excentric loading the hooping reinforcement is not to be taken into account in calculating the stresses due to the moments.

The pitch of the hooping must not exceed ⅕ of the smallest diameter of the hooped core. The imaginary area A is multiplied by the safe resistance of the concrete to simple compression.

The Austrian Government give special coefficients of reduction for the safe compressive resistance of the concrete for compression pieces when these have to be calculated for flexure. These are :

(*a*) For a central loading:—$\alpha=\left(1{\cdot}12-0{\cdot}006\frac{L}{r}\right)$ where L is the length and r is the least radius of gyration of the piece.

(*b*) For eccentrical loading the coefficient of reduction is $\frac{1-\alpha}{\alpha}$. The value of α being found as for (*a*).

When considering the flexure of the reinforcement, the compressive resistance (f) in the steel must be reduced to f_k for the ratio $\frac{L}{r_s}$ = 10 to 105.

(*a*) $f_k=\left(0{\cdot}816-0{\cdot}003\frac{L}{r_s}\right)f$.

(*b*) For the ratio $\frac{L}{r_s} > 105$:—$f_k=5580\left(\frac{r_s}{L}\right)^2 f$.

L being the length of the reinforcement, r_s its radius of gyration, and f being found as for a compression piece not subject to flexure.

Other authorities give special formulæ based on Euler's or Gordon's formulæ.

The calculations for flexure of rectangular beams are generally similar, being the same as those given in several well-known text books, where the straight line stress-strain relation is assumed.

APPENDIX.

WHILE this article was in the press the Government amendments to the Building Bye-Laws for Johannesburg, issued on March 12th, 1908, have come to hand. These have clauses relating to the use of reinforced concrete; a short summary of these is given :

Cement.

Only high-grade Portland cement to be used to comply with the British Standard Specification, and have a tensile strength of at least 500 lb. per sq. in.

Aggregates (Sand and Stone).

To be clean and sharp, stone to be clean broken rock or stone, to pass a ¾-in. screen.

Concrete.

Ultimate crushing resistance at least 2,000 lb. per sq. in after 28 days. Resistance ascertained by tests on at least six specimens. The proportions to be 1 : 2 : 4, or such as will provide above crushing resistance, and in which mortar fills all voids in stone. Mixture is to be a "wet" one.

Erection.

Steel to be entirely surrounded by concrete to extent of at least 1½ times its diameter, or 1 in. if such dimension be greater. Outside cover in columns at least 1¼ in. Joints in longitudinal rods of columns only made at floors or other points of lateral support, ends of the bars machined to give true bearing and to have a tight sleeve over joint. Where designed to resist wind pressure rod and sleeves to be threaded.

Fire Resistance.

Where required to be fireproof, thickness of at least 1 in. of concrete to be added to each face, in addition to that required above.

Testing.

Structures designed and constructed to withstand load at least twice that which they are intended to carry, without sign of failure, or in case of beams or floors twice intended load without showing deflection exceeding $\frac{1}{700}$ the span.

Allowable Stresses.

$\frac{Es}{Ec}=10$. Resistance of concrete in tension neglected.

Nature of Stress.	Mild Steel, lb. per sq. in.	Concrete, lb. per sq. in.
Compression	14,000	350
Tension ...	16,000	Nil
Shearing ...	10,000	50
Adhesion ...	—	50

If above adhesive resistance exceeded, provision made for transmission of extra shear to steel, by shaping steel in suitable form or in some other equally efficient manner.

Length of columns not to exceed 15 times least transverse dimension of column. Transverse ties or spiral bindings in columns spaced at distance apart not greater than least side of column.

*Walls.**

For skeleton buildings or buildings where weight of wall panels is borne by beams at each floor level, walls may be of reinforced concrete at least 6 in. in thickness, with increase of 1 in. thickness for every two storeys or part thereof downwards from top. Such walls reinforced horizontally and vertically. Horizontal rods of steel at least ¼-in. diam., spaced not more than 24 in. apart, and vertical rods of steel at least ¾-in. diam. spaced not more than 18 in. apart. All such rods wired together at crossings, and horizontal rods secured to steel columns or reinforcement in piers. Extra reinforcements provided around openings.

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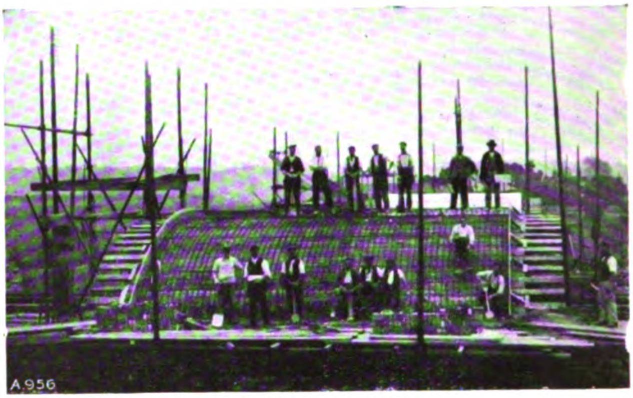
* These rules only to apply to wall panels not exceeding 300 sq. ft. in area between piers and beams. Beams carrying no additional load, with exception of wood or corrugated iron roofs. Where weight of wall not borne at each floor level, or where wall is so carried and exceeds 300 sq. ft. area, thickness shall not be less than 75% of that prescribed for brick walls, and reinforcement shall be arranged as above and be at least 1% of concrete area.

REINFORCED CONCRETE ON THE GREAT EASTERN RAILWAY.

PART I.—BRIDGES.



DEEPHAMS FARM ROAD BRIDGE.

By EDWARD A. WILSON, A.M.Inst.C.E.

Assistant Engineer Great Eastern Railway.

In an earlier issue we dealt with reinforced concrete work on the Great Western Railway. In this number we have pleasure in presenting particulars of similar work on the Great Eastern Railway.

It is pleasurable to observe the advance recently made in the introduction of reinforced concrete work by our great railway companies.—ED.

IN 1899 the Great Eastern Railway Company obtained Parliamentary powers to widen their Cambridge main line between Temple Mills and Broxbourne Junction, subsequently abandoning the northern part beyond Picketts Lock Lane in 1906. In connection with the remaining portion now in course of construction, reinforced concrete has been largely utilised in the over-line bridges.

Between Angel Road and Ponders End Stations the Company were under statutory obligations to construct bridges, one in lieu of the occupation crossing of the Edmonton Urban District Council at Deephams Farm Road, and another to carry a new road substituted for the old existing public road crossing at Picketts Lock Lane.

In both these cases, owing to the permissible length of the approaches being limited, the depth of the construction was reduced to a minimum, and it was considered desirable, in view of the possibility of future development, to use one span only across the Railway Company's property, a distance approximately of 90 ft.

It was necessary also to construct two other over-line bridges at Tottenham and Angel Road Stations, the former a Middlesex County road over which provision had to be made for an extension of the Metropolitan Electric Tramway Co.'s lines, and the latter a district road under the jurisdiction of the Edmonton Urban District Council.

Deephams Farm Road.—This bridge has one span, 89 ft. 6 in. in length across the main roads and reception sidings, with a side arch on the western side of 30 ft. span for the accommodation of the Edmonton Urban District Council, and two arches of 35 ft. and 30 ft. span respectively on the eastern side for the Metropolitan Water Board and Edmonton Urban District Council.

Dealing with the main span, it was found that by adopting the ordinary construction of cross girders ad brick jack arches it would be necessary for the former to occur at 5 ft. intervals, and on account of the very heavy dead load great expense would be incurred in constructing girders and abutments sufficiently strong to cope with this, but that by utilising reinforced concrete in place of brickwork, keeping the rise the same, the span could be doubled and the number of cross girders required would consequently be halved; the total dead load to be carried being reduced approximately by one-third; thus a span of 10 ft. with a rise of 1 ft. was found sufficient.

As the proportion of span to rise was large and the thickness at the crown had to be kept as small as possible, the "Monier" formula for elastic arches was adopted, a method which, though not entirely correct, is near enough for practical purposes:—

Let p = Total load per sq. in. of surface.
K = Safe load of concrete (1 : 4).
l = Span in in.

then B = Depth of arch $\frac{p \times l}{K} \times \left({\cdot}62 + \sqrt{0{\cdot}38 + \frac{1}{117}\,\frac{K}{p}} \right)$

$p = 8{\cdot}6$ lb. per sq. in.
$K = 400$ lb. (·18 ton) per sq. in.
$l = 120$ in.

$$\text{therefore } B = \frac{8{\cdot}6 \times 120}{400} \times \left({\cdot}62 \times \sqrt{{\cdot}38 \frac{400}{117 \times 8{\cdot}6}} \right)$$
$$= 2{\cdot}58 \times (1{\cdot}48)$$
$$= \text{(say) } 4 \text{ in.}$$

The sectional area of the rods (Fe) was determined by the formula $Fe = \frac{1}{4} \times \frac{K}{K_1} \times B$

where K^1 = safe load for concrete = ·18 tons per sq. in.
K_1 = safe load for iron rods 6·4 tons per sq. in.

therefore $Fe = \frac{1}{4} \times \frac{{\cdot}18}{6{\cdot}4} \times 4 = {\cdot}028$ sq. in. for 1 in. width
or ·112 sq. in. for 4 in. width of arch
or $\frac{3}{8}''$ dia. rods 4 in. apart.

The cross, or distributing rods for arches were made $\frac{3}{16}$ in. dia., 4 in. apart, thus forming with the main rods 4 in. × 4 in. meshes.

The arches were increased in thickness to 6 in. at the springings.

Let N = pressure at F.
S = sectional area of arch for 1 yd. width.
M = static moment of N.
R = moment of resistance of the sub-area S.

For the 35 ft. arch a thickness of 12 in. at the crown and 16 in. at the springing was assumed, and the necessary reinforcing for these dimensions arrived at by calculations based on the ordinary graphic method of determining the line and intensity of the thrust.

The sectional area *S* is exposed to three different stresses, the first resulting from the normal pressure on this section produced by *N*; the second resulting from the circumstance that *N* is situated outside the sectional area *S* at a distance of 8·25 in. from the centre line. The latter stress is positive above the neutral axis, and negative below it.

Maximum of pressure $= Sp = \frac{N}{S} + \frac{M}{R}$ Maximum tension $= St = \frac{N}{S} - \frac{M}{R}$

For 1 yd. width.

$N = 16{\cdot}5$ T; $S = 13{\cdot}5 \times 36$; $M = 8{\cdot}25$ N; $R = 1/6 \times 36 \times (13{\cdot}5)^2$

$$\text{or} \begin{cases} Sp = \frac{16{\cdot}5}{36 \times 13{\cdot}5} + \frac{8{\cdot}25 \times 16{\cdot}5}{6 \times (13{\cdot}5)^2} = 0{\cdot}034 + 0{\cdot}125 = +0{\cdot}159 \text{ ton per sq. in.} \\ St = \frac{16}{36 \times 13{\cdot}5} - \frac{8{\cdot}25 \times 16{\cdot}5}{6 \times (13{\cdot}5)^2} = 0{\cdot}034 - 0{\cdot}125 = -0{\cdot}091 \quad ,, \quad ,, \end{cases}$$

According to the diagram the distance A O from the neutral axis

$$= \lambda = \frac{0{\cdot}159 \times 13{\cdot}5}{0{\cdot}159 + 0{\cdot}091} = 8{\cdot}59''$$

thus area of tension

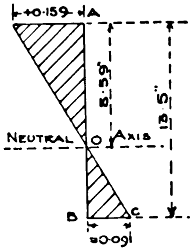
$$= O\ B\ C$$
$$= \tfrac{1}{2}\ (13{\cdot}5 - 8{\cdot}59) \times 0{\cdot}091 = 0{\cdot}2234$$

hence the total tensile stress for 1 yd. width

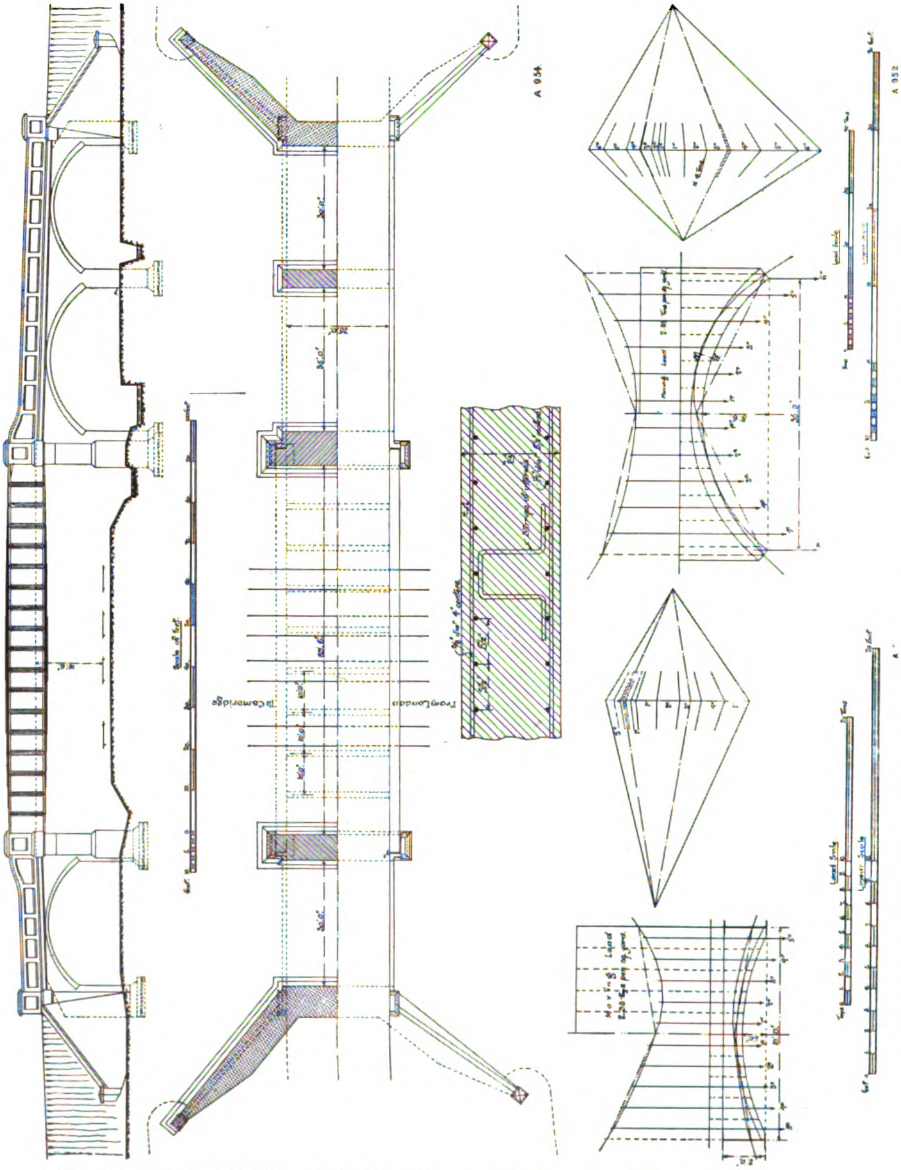
$$= 0{\cdot}2234 \times 36'' = -8{\cdot}04 \text{ T}$$

and the sectional area of rods for a width of 1 yd.

$$= \frac{8{\cdot}04}{6{\cdot}5} = 1{\cdot}24 \text{ sq. in.}$$



The reinforcing was carried out, therefore, with ½ in. dia. round rods, each having a sectional area of 0·196 sq. in., giving $\frac{1{\cdot}24}{0{\cdot}196}=6\frac{1}{3}$ rods per yd., or a central distance of $\frac{36}{6\frac{1}{3}}=5{\cdot}7$ in. between rods.



Graphic Research for Arch of 35ft. Span.

Graphic Research for Jack Arch of 10ft. Span.
Deephams Farm Road Bridge on Great Eastern Railway.

Transverse distributing rods ⅜ in. dia. were placed at 4 in. centres.

Bent iron rods were introduced at a distance of 3 ft. 6 in. for the double purpose of taking up the shear and keeping the upper and lower reinforcement in position whilst the concrete was being rammed.

The remaining arches were similarly reinforced, and for uniformity of appearance the same depth was maintained.

All arches were composed of 1 part of Portland cement to 4 of aggregate, consisting of washed pit gravel, one-third being sand, the remainder of various sizes, all to pass a ¾-in. mesh. The backing to these arches was composed of the same materials but mixed in the proportion of 1 part of Portland cement to 10 of aggregate. This backing was brought to a level surface, and on this a camber of ½ in. to 1 ft. of width, composed of 4 to 1 cement concrete, was formed to carry the paving.

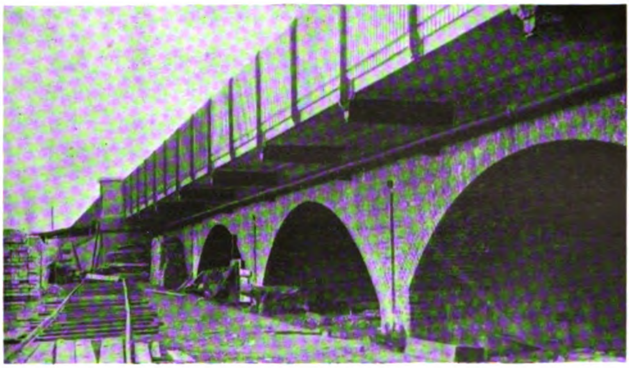
Picketts Lock Lane Bridge.—This bridge was constructed simultaneously with the former, and in general construction, both as regards design and reinforcement, it is the same, the chief difference being that the width between parapets is 30 ft. in this case instead of 25 ft.

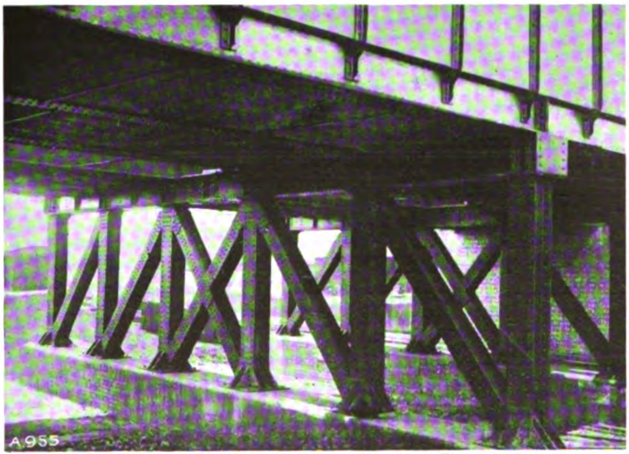
Ferry Lane Bridge.—This bridge, 50 ft. in width, and now nearing completion, is to replace a smaller structure.

In order to continue the road traffic whilst the work was in progress it was necessary that the bridge should be capable of being constructed half at a time, the existing road being utilised whilst the northern section was being built, and the road then turned for the purpose of completion. For this reason the spans, three in number, over the railway, were formed of shallow box girders at right angles to the line of rails at 9 ft. 8½ in. centres, bearing Jack arches of similar construction to those at the former bridges.

The eastern approach is carried on arches. As the footpaths were to carry a live load of 160 lb. only to the sq. ft., to save the expense of heavy foundations and superstructure, it was decided to adopt a cantilever construction supporting slabs 3 in. thick formed of 4 to 1 granolithic concrete and reinforced with Expanded Metal.

Deephams Farm Road Bridge, Great Eastern Railway.





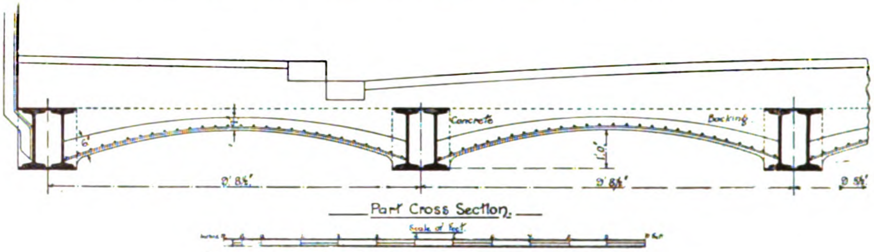
Ferry Lane Bridge, Great Eastern Railway.

Reinforced Concrete in Bridges of the Great Eastern Railway.

Angel Road Bridge.—This bridge, now in course of construction, is to carry the public road over the railway in place of a level crossing.

The experience gained in the utility of reinforced concrete being entirely satisfactory, it was determined to carry out the whole of the work in this material, and when completed it will be one of the largest bridges and approaches in reinforced concrete in the United Kingdom.

A scheme was prepared and tenders invited, it being permissible for any contractor to submit an alternative tender in any proprietary system.



FERRY LANE ROAD BRIDGE, GREAT EASTERN RAILWAY.
PART SECTION THROUGH ROADWAY OVER RAILWAY SPANS.

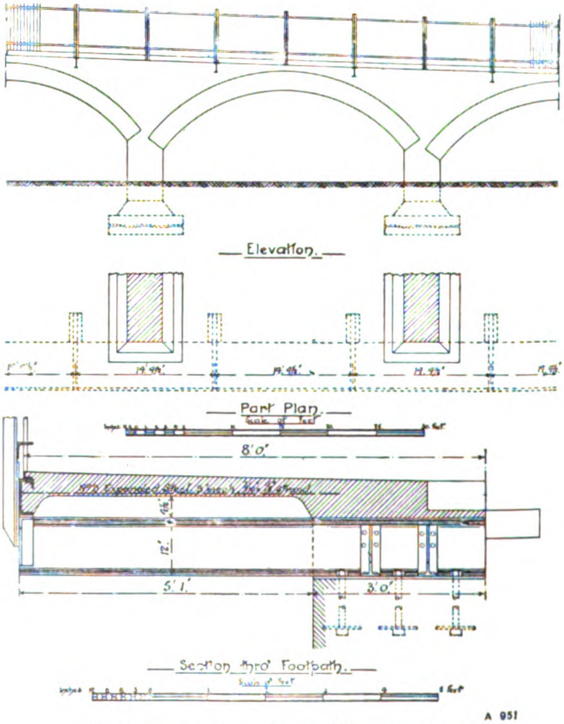
A design on the Considère system was accepted, consisting of 17 equal spans, three of which are on the curve, designed as continuous girders, 42 ft. 9 in. between the centres of bearing and 5 ft. 4½ in. apart, carrying a roadway 24 ft. wide, together with 2 ft. of footway on both sides, the remaining 6 ft. of the latter, together with the parapets, being supported by cantilevers.

The flooring is 6 in. thick, weighing together with the road metalling ·77 tons to the super yd., to carry a load of 6½ tons on a wheel 20 in. wide, this weight assumed as being transmitted through the road metalling at an angle of 1 to 1 and into the body of the flooring at an angle of 1½ to 1, the total distributed super load being therefore 3·2 tons per super yd.

For a 5 ft. 4½ in. span 1 yd. wide the dead load is 1·8 super yd. × 0·77 tons = 1·4 tons.

The super load is 1·8 super yd. × 3·2 T = 5·76 tons.

The flooring is continuous, so that taking the most unfavourable loading the bending moments in ton inches for 1 yd. in width are as follows :—



FERRY LANE BRIDGE, GREAT EASTERN RAILWAY.
DETAILS OF REINFORCED CONCRETE FOOTPATH.

End bays :— dead + ·08 (1·4 T × 64·5 in.) = + 7·20
super — ·02 (5·76 T × 64·5 in.) = — 7·43
,, + ·10 (5·76 × 64·5 in) = + 37·15

or together a maximum of 44·35 and a minimum of —0·23 (negligeable). In the above equations the first factor is derived from the theory of the three moments.

Similarly the middle bays give a maximum of +32·97, a minimum of —13·47, and over supports a negative moment of —54·6 is found.

Since the spans are taken from centre to centre of supporting girders these moments are reduced by the coefficient of rigidity which is equal to the clear span divided by the centre to centre span, all squared, that is $\left(\frac{5'\ 4\frac{1}{2}'' - 1'\ 0''}{5'\ 4\frac{1}{4}''}\right)^2 = 0{\cdot}67$.

Again, as the slabs are fixed on all four sides, there is a further reduction of which the coefficient is $\frac{L^4}{L^4 + B^4}$ where L is the length and B the breadth of the slab, that is

$$\frac{(7'\ 1\tfrac{1}{2}'')^4}{(7'\ 1\tfrac{1}{2}'')^4 + (5'\ 4\tfrac{1}{2}'')^4} = 0{\cdot}76.$$

These reductions together equal ·67 × ·76 or ·51, but taking ·7 to allow for impact, the bending moments are, for end bays 44·35 × ·7 or +31·05; for middle bays 32·97 × ·7 or +23·10 maximum, and —13·47 × ·7 or —9·43 minimum; over supports —54·6 × ·7 or —38·22.

The following static calculations are based upon the Prussian Official formulæ *(derived from the same data as those published by the R.I.B.A. Joint Committee in 1907).*

Here *x* is the distance in inches of the neutral axis from the top of section; *b* the width; *h* the depth of slabs in inches; *Fe* the sectional area of reinforcement in sq. inches; *σfe* the maximum stress in steel; *σc* the maximum stress in concrete in tons per sq. inch; M the bending moment in ton inches.

$$\text{(i)}\ x = \frac{15Fe}{b}\left(-1 + \sqrt{1 + \frac{2bh}{15Fe}}\right) \qquad \text{(ii)}\ \sigma fe = \frac{M}{Fe\left(h - \frac{x}{3}\right)} \qquad \text{(iii)}\ \sigma c = \frac{2M}{bx\left(h - \frac{x}{3}\right)}$$

Then for the roadway flooring in the end bays M is 31·05, assuming *Fe* is 0·9 sq. in. (6 No. ⅜" and 1 No. ½" round rods); *h* 5·4 in., and *b* 36 in.

$$x \text{ is } \frac{15 \times {\cdot}9}{36}\left(-1 + \sqrt{1 + \frac{2 \times 36 \times 5{\cdot}4}{15 \times {\cdot}9}}\right) \text{ or } 1{\cdot}7 \text{ in.}$$

$$\sigma fe \text{ is } \frac{31{\cdot}05}{{\cdot}9\left(5{\cdot}4 - \frac{1{\cdot}7}{3}\right)} \text{ or } 6{\cdot}8 \text{ tons per sq. in.}$$

$$\text{and } \sigma c \text{ is } \frac{62{\cdot}10}{36 \times 1{\cdot}7\left(5{\cdot}4 - \frac{1{\cdot}7}{3}\right)} \text{ or } {\cdot}202 \text{ tons per sq. in.}$$

So with the centre bays, the rods found necessary were 6 No. $\frac{5}{16}$ in. and 1 No. ½ in. per yd. in width, and over supports 7 No. ⅜ in. and 4 No. $\frac{5}{16}$ in.

The longitudinal girders are stressed more by a super load of 2½ cwt. per sq. ft. than by a roller, the former loading was taken and the maximum B.M. (reduced by the coefficient of rigidity) was found to be, over end bays +2213; over first support —2828; over others —2400 and over middle span +1587 maximum and —130 minimum.

With the same symbols as before, and with *d* as the thickness in inches of the slab, and *y* the distance in inches between the neutral axis and the centre of compression, for "ribbed plates" the formulæ become

$$\text{(i)}\ x = \frac{bd\frac{d}{2} + 15Feh}{bd + 15Fe} \qquad \text{(ii)}\ y = x - \frac{d}{2} + \frac{d^2}{6(2x - d)}$$

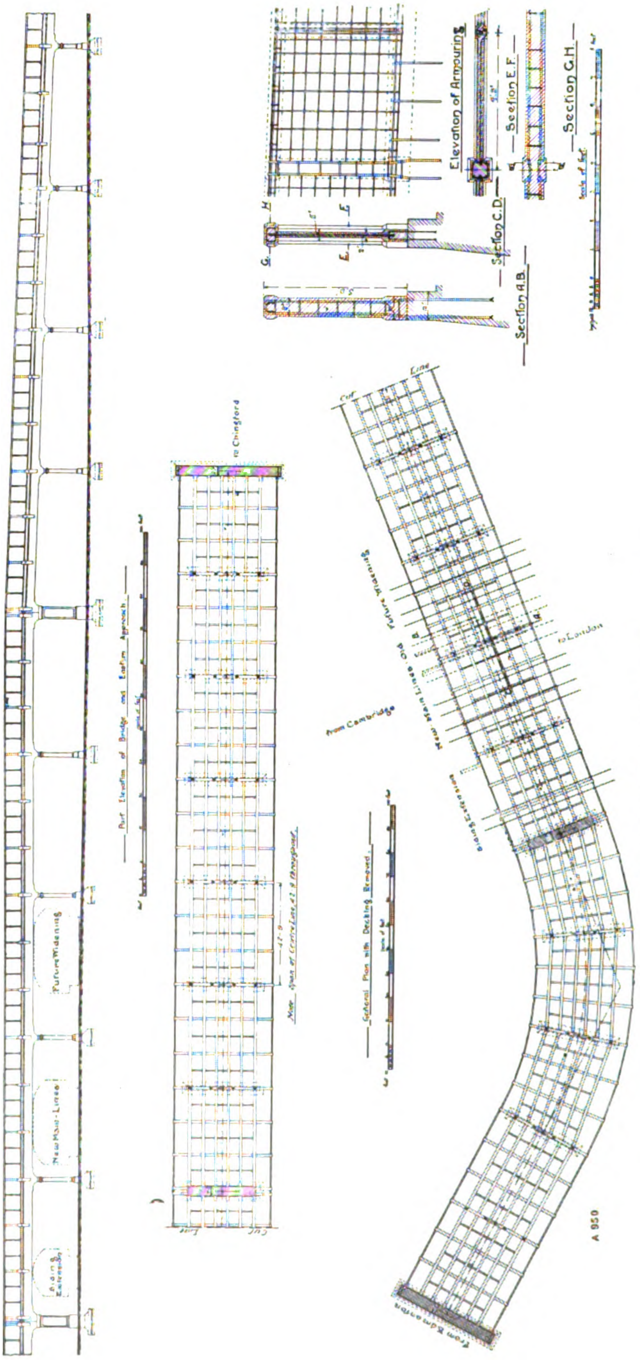
$$\text{(iii)}\ \sigma fe = \frac{M}{Fe(h - x + y)} \qquad \text{(iv)}\ \sigma c = \frac{\sigma fe}{15} \times \frac{x}{h - x}$$

on substituting the values in the above it was found with *h* equal to 29 in., *b* equal to 64·5 in., and *d* equal to 6 in., that in the end bays 2 No. 1⅜ in. and 6 No. 1¼ in., and in the middle bays 6 No. 1⅛ in. and 2 No. 1 in. rods were required.

At the points where the greatest negative moments occur the section of steel used in the upper part was arrived at by taking the first set of formulæ, since the concrete of the slab is in tension, and is therefore to be neglected in calculating the strength of the beam. Over the supports, in order to keep the beams of reasonable and convenient dimensions, *h* was made 41 in., and this entailed a compressive stress in the lower concrete of ·60 tons per sq. in. The excess is met by spiralling the lower part of the beam as shown in the sections of the bridge, the amount being found by the following method, due to M. Considère :—

S the safe load per sq. in. of spiralled section; p the percentage of spiral rod, p_1 the percentage of longitudinal rods to unit volume of concrete. Then

$$S = \cdot45\left(1+\frac{32p+15p_1}{100}\right)$$



ANGEL ROAD BRIDGE, GREAT EASTERN RAILWAY.

In this case the spiral is a $\frac{3}{4}$-in. rod at 2-in. pitch—that is, in a lineal foot there are 6×37 in. (say) ×·05 sq. in., or 11 cu. in. of steel per 13 in.×13 in. ×·83 (ratio of octagon to square) ×12 in. or 1,680 cu. in. of concrete—that is, ·66 per cent. The two longitudinal rods equal 29·5 cu. in., or 1·75 per cent., so that S is ·66 tons per sq. in.

The flooring to the footpaths is capable of supporting a superload of 160 lb. per sq. ft., and the reinforcement necessary was found by the first formulæ to be $\frac{3}{8}$-in. rods at 5-in. centres.

The girder under the parapet has reinforcement calculated in the same manner as the longitudinal girders, consisting of 2 No. $\frac{5}{8}$ in. and 2 No. $\frac{7}{16}$ in. for the end bays: 2 No. $\frac{1}{2}$ in. and 2 No. $\frac{3}{8}$ in. for the middle bays, 6 No. $\frac{1}{2}$ in. over the supports with a $\frac{1}{4}$-in. spiral at 2-in. pitch.

The greatest load taken by a column is 120·2 tons, the spiral used is $\frac{5}{16}$ in. at 2 in. pitch and 13 in. dia., this is ·84 per cent. of the concrete; the 8 vertical rods are $\frac{5}{8}$ in. dia., and amount to 1·31 per cent. of the concrete.

Substituting these values in the Considère formula, S the safe load is equal to $0{\cdot}45\left(1+\frac{32\times{\cdot}84}{100}+\frac{15\times1{\cdot}31}{100}\right)$ or ·66 tons per sq. in. of the "equivalent" sectional area of the column.

This figure must be reduced for lateral deflection and for "free ends," the factor n is equal to $1+\frac{A\times L^2}{10.000\times I}$ where L is the length of the column in inches, I the moment of inertia of the section, and A the equivalent sectional area of the column in sq. in. Four only of the vertical rods will be considered as resisting deflection, so that the equivalent area is $15^2\times{\cdot}83+4\times{\cdot}307\times15$ or 205 sq. in., and I is $\frac{1}{18}(15)^4+4\times{\cdot}307\times15\times(6)^2$ or 3,475 in.; thus n is

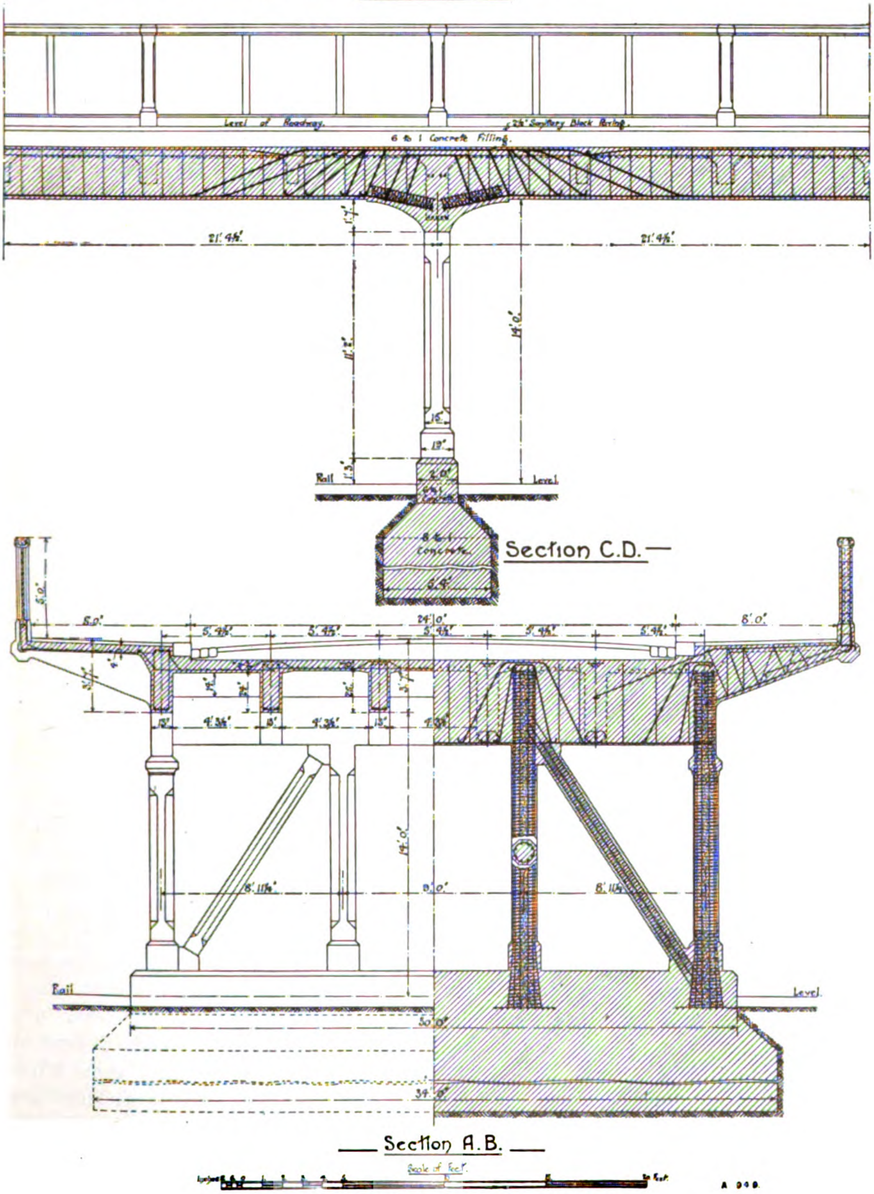
$$1+\frac{205\times144\times144}{10{,}000\times3475} \text{ or } 1{\cdot}122.$$

The safe load, taking lateral bending into account, is therefore equal to $\frac{\cdot 66}{1 \cdot 122}$ or ·59 tons per sq. in., and the total safe load is 205 × ·59, or 121 tons

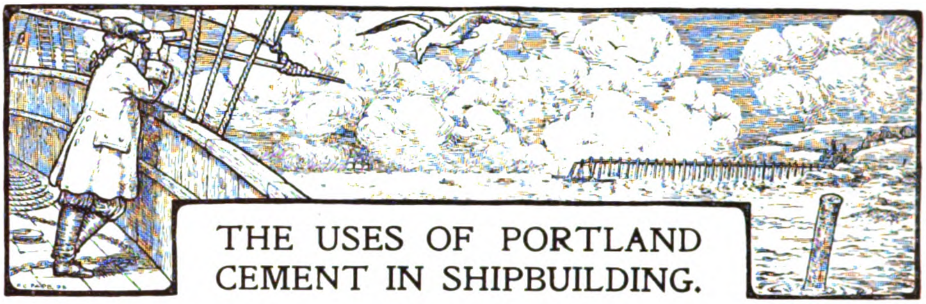
Considering that the *free* length of the column is less than 144 in., for both ends are fixed, there is a factor of safety of not less than 5, especially as the loads taken are those used in calculating the beams, and for that purpose were increased beyond their true weights to allow for impact.

A special feature of this bridge will be the parapets; these have to be of a very light construction as they are erected at the extreme end of the cantilevers.

The panels are in separate slabs on account of thinness and design, to avoid expensive shuttering and cracks due to thermal stresses.



Angel Road Bridge, Great Eastern Railway.



THE USES OF PORTLAND CEMENT IN SHIPBUILDING.

By **ALFRED SMITH**, Sunderland.

The general uses of Portland Cement for building purposes are far better known than those to which this material is applied on board ship.

At a time when there is some discussion as to the advantages and disadvantages of Portland Cement amongst shipbuilders, the article given below should be appropriate.

Our view is that for all practical purposes Portland Cement is unsurpassed as a general protective against corrosion, and for filling small voids. For ship repair work it is a veritable boon to all concerned.—ED.

THE general public are probably fairly familiar with the varied purposes for which Portland cement is used in buildings, etc., but it may be doubted whether they are as fully aware of the part it has played, and still plays, in the construction and repairing of ships and in their efficient maintenance.

It may perhaps therefore be useful first to mention in which parts of a vessel it is principally used before entering upon an examination of its merits from the point of view of the shipbuilder or shipowner.

WHERE PORTLAND CEMENT IS USED ON SHIPS.

When the use of iron, and later, steel, became general as a shipbuilding material it was soon recognised that some means would have to be found to protect those portions of the structure, particularly in which water gathered, either as the result of drainage or from other causes. It was realised that to allow water, however small in quantity, to lie on the iron or steel bottom of a ship, or to leave crevices to be filled with refuse or dirt that would absorb moisture could only have one result, and that an all-important one—namely, the destruction in time by corrosion of those parts of the structure. It was found, moreover, that certain cargoes exercised to a great extent an injurious effect upon the iron or steel as the result of chemical action. It was obvious that the water would drain itself to the bottom of the ship, and that in this part the likelihood of damage was the greatest. It was to this part of the vessel therefore that attention was first directed as to probable damage resulting from corrosion. The principal portion therefore of an iron or steel ship in which some preservative was first seen to be necessary was the bottom. Portland cement was found to answer the purpose admirably. The plating and rivet heads, as well as the frame flanges, were practically buried under a thick covering of cement, and the floors, keelsons, etc., well coated with cement wash, which it was found effectually protected the iron or steel. And even with the advent of the double-bottom vessels Portland cement played equally as large a part, the bottom plating, rivet heads, floors, angles, intercostals, etc., inside the double bottom being treated as before mentioned in open floor vessels.

Next to the bottom, but first in importance in a double-bottom ship, cement is used largely in the bilges and water courses. The shell, tankside angles, and bracket angles are well covered, the cement making it possible for the water to run freely through the drain holes in the bracket plate. Where the bilge water is run or drained, as is frequently the case, into wells, these wells are in turn also cemented. Not only are the bottom plating, lower portion of floors, frames, etc., in ballast tanks and bilges and wells treated with cement, but the internal parts of fresh water tanks are also well coated with it instead of being painted, while the same treatment is applied to the double-bottom floors under the boilers, engines, hold tanks, and tunnels wherever moisture is likely to gather. Cement is also applied in gutter waterways and between the shell and stringer angle bars in 'tween decks, and other spaces where frames run up through the decks are filled in with it. It is also largely used on the decks of cattle-carrying steamers in way of the cattle accommodation. It is also applied to the bosses of propellers when loose blades are used, the nuts, as well as the propeller or tail shaft nut, being covered.

Generally it may be said that wherever there is a crevice where water or rubbish is likely to gather it is filled with cement, which ensures as far as possible a smoothness for the easy flow of water, thus securing the cleanliness and preservation of the ship. It may be noted that with few exceptions the cement is mixed with a certain proportion of fresh water sand. The proportions vary from equal quantities of cement and sand to two of cement and one of sand, or one of cement and two of sand, according to the purpose for which it is required or the experience of the user. In speaking of cement it must be understood that we refer to the mixture. Portland cement unmixed with sand is sometimes placed on the bottom of oil tanks in oil tank steamers after they have been tested. It is usually applied about one inch thick, and it has not been found to be affected by chemical action to any great extent. Such briefly are the uses to which Portland cement is put in the building of a vessel, and it will be noted that in many respects the part it plays is not unimportant. Much depends upon it for the end sought in all cases is the same—namely, the preservation of those parts of the ship's structure as are most liable to be impaired by corrosion arising from moisture. We will see later that Portland cement is useful in other directions, such as for repair purposes, but we may perhaps here mention only one serious objection against it—namely, that of weight—which is also being met in a practical manner.

OVERCOMING DIFFICULTIES AS TO WEIGHT.

In respect to this question of weight, it is obvious that the presence in a ship of a large amount of cement involves a corresponding loss of dead weight capacity. This point, which at all times weighs with shipowners, is, however, more than met by the cheapness of Portland cement as compared with any of the so-called substitutes.

During the last decade the adoption of joggled plating has appreciably reduced the quantity of cement required in the bottom, which correspondingly saves weight in a practical manner without the useful qualities of Portland cement being lost.

But the great advantage of Portland cement over compositions, etc., is that it is so conveniently applied, no special preparation of the surfaces being required, and when being used in confined spaces it gives off no fumes. In such spaces there is a danger with bitumastic cement which does not exist with Portland. Again, Portland cement is applied wet, whereas with bitumastic composition or paint the surface must be quite dry, otherwise it will not adhere. In many cases this point in favour of Portland is important.

PORTLAND CEMENT FOR SHIP REPAIRS.

Perhaps, however, one of the points most strongly to be urged in favour of Portland cement is its usefulness in the temporary but effectual stopping of leaks, which would otherwise be a source of serious loss to the shipowner. This is generally recognised as one of its great advantages. So much so, indeed, that formerly it used to be a common practice to include in the equipment of a ship a few tons of the cement as a stand-by to use in emergencies in case the vessel happened to sustain damage abroad where it could not be obtained. This is not so essential to-day, as it can be obtained abroad more easily than used to be the case. Numerous cases of damaged vessels being brought home safely by the use of Portland cement even loaded with valuable cargoes might be mentioned, but we will content ourselves with one which came under our own notice. A few years ago a sailing ship went aground in the Hooghly River in India and damaged her bottom rather extensively, the plating being corrugated almost right fore and aft, with the result that she was found to be leaking badly. It was determined to bring her home for repairs, and to effect this the whole of the inside of the bottom was covered with Portland cement tapering in thickness from 12 in. at the middle line to 4 or 5 in. at the sides. The vessel then loaded a cargo and brought it safely to this country, where she was docked and repaired. It was found that, although the vessel had encountered heavy weather on the passage, the cement had effectually prevented the slightest trace of water reaching the cargo; and those who were engaged upon the work of removing the cement preparatory to repairing the bottom testified to the difficulty experienced in doing so.

Many vessels abroad receiving damage to the fore end—a part of a ship's structure particularly liable to be damaged—have been brought home for repairs after being similarly treated. A few tons of cement have been filled into the fore peak, which have stopped the leak until permanent repairs could be effected. A notable instance of this was in the case of the "Winkfield," which during the South African War was taking some Yeomanry out to the Cape when she collided with the "Mexican." The fore end of the "Winkfield" was completely stove in. She was temporarily repaired at the Cape by filling in the forepeak entirely solid with Portland cement, and in that condition she returned to this country for permanent repairs. In many instances, too, where vessels have received under-water damage while alongside a wharf it has been found very difficult to effect repairs, the vessels perhaps being partly loaded. In such cases Portland cement has been used most effectually. A square has been formed round the damaged portion the depth of the spar ceiling and cement run in.

Generally speaking, both as to its preservative character when applied to iron or steel, or as a handy means of dealing quickly with a leak, Portland cement is held in high esteem still.

SUMMARY.

Some owners, for various reasons, may favour compositions and paints, but the almost universal use of Portland cement in the mercantile marine may be taken as the best evidence of its great utility.

REINFORCED CONCRETE FOR POST OFFICE BUILDINGS.

WORK ON THE WESTERN DISTRICT POST OFFICE, LONDON.

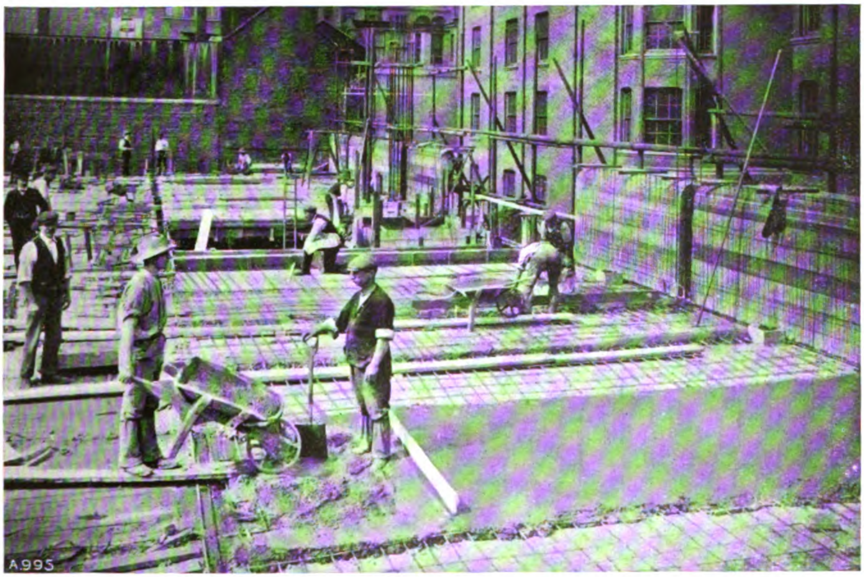
We have previously dealt with some of the Post Office work being executed under the direction of H.M. Office of Works. It will be remembered that the General Post Office works at St. Martin's-le-Grand are now nearing completion, and will be the most important example of reinforced concrete work in this country.

In the current issue we are presenting particulars of one of the district post offices—viz., the Western District Post Office in course of construction near Cavendish Square, and it is pleasing to note from an answer given by the First Commissioner of Works to an enquiry in the House of Commons that the saving in employing reinforced concrete for this class of structure is substantial.—ED.

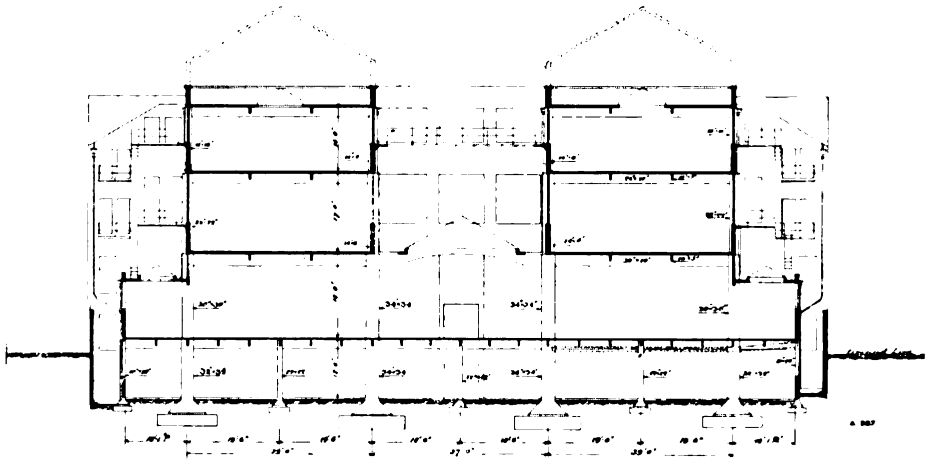
WESTERN DISTRICT POST OFFICE, LONDON.

THE Western District Post Office, London, which is being erected between Cavendish Square and Wimpole Street, under the direction of H.M. Office of Works, is now in course of construction. The contractors are the licensees of the Coignet system, viz., Messrs. King and Co., of London.

The building, which comes within the purview of Sir Henry Tanner, I.S.O., principal architect of H.M. Office of Works, comprises a block of some 190 ft. frontage by 156 ft. depth, having a basement, ground floor, and first and second

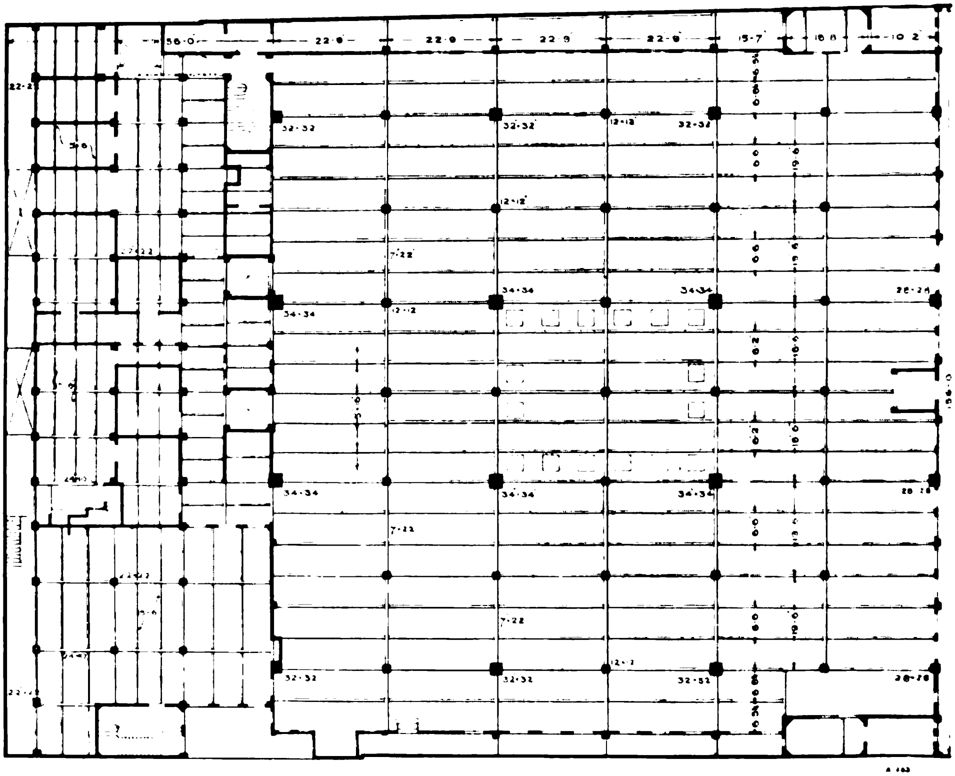


THE WESTERN DISTRICT POST OFFICE, LONDON
(Reinforced concrete floor on the Coignet system in course of construction).

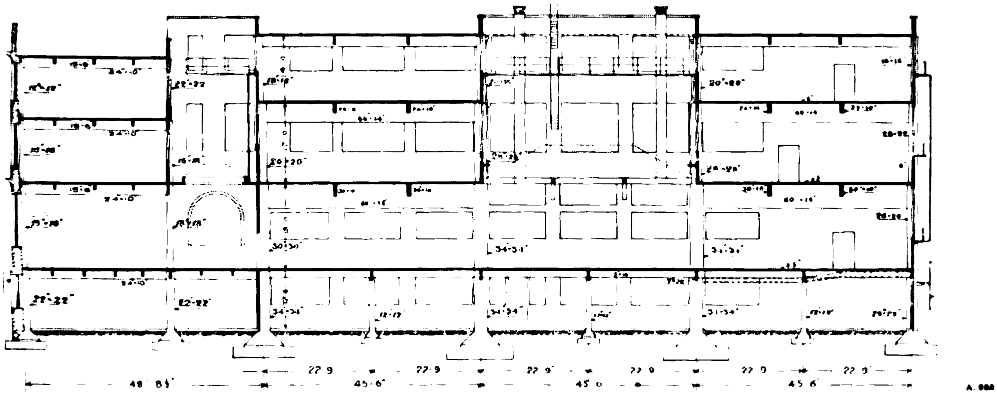


Western District Post Office, London (Transverse section).

storeys, light being obtained principally in the front and back. There is also some good side lighting, and a central light court.

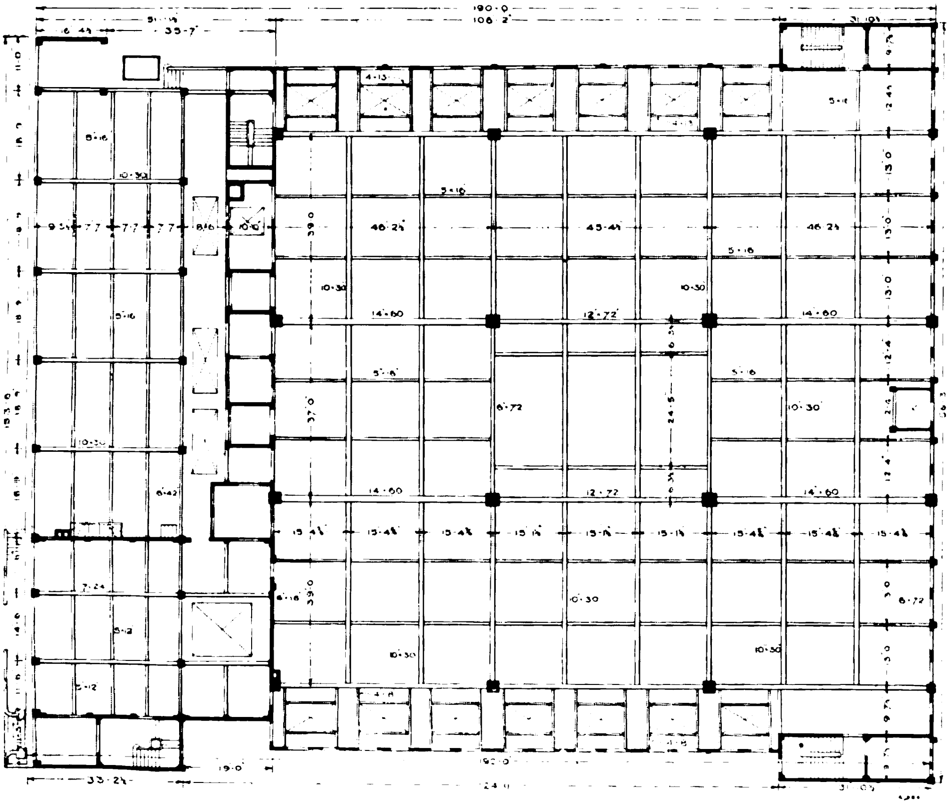


Western District Post Office, London (Basement plan).



WESTERN DISTRICT POST OFFICE, LONDON (Longitudinal section).

The plans and sections explain themselves, indicating how the principal loads have been brought over the fewest possible points.

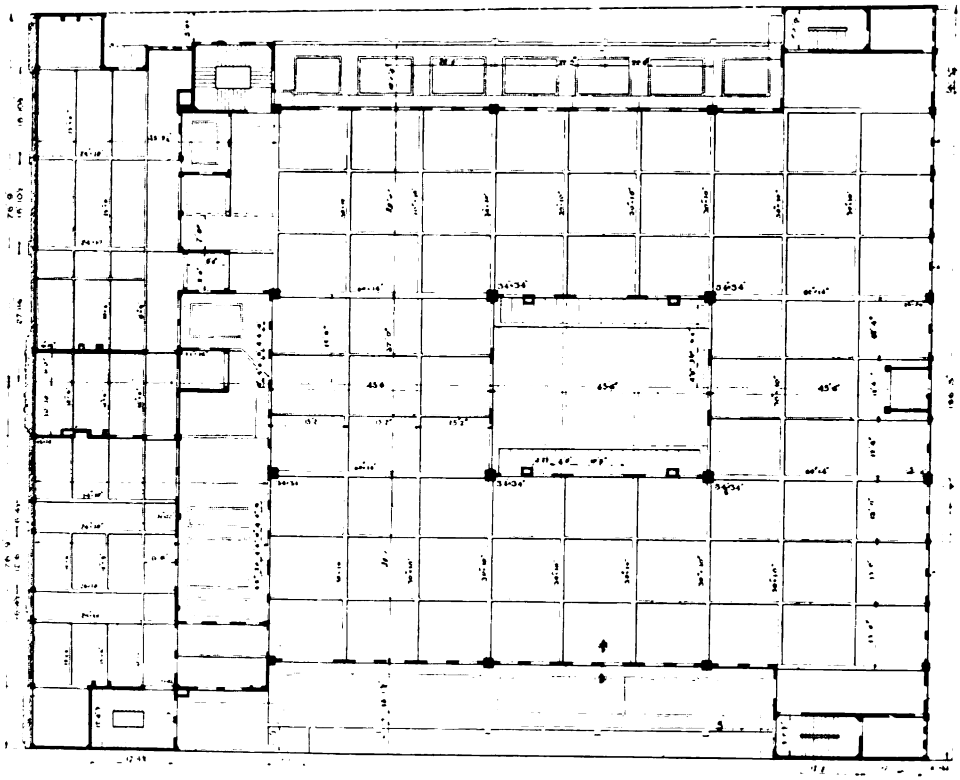


WESTERN DISTRICT POST OFFICE, LONDON (Plan of ground floor).

In the principal rooms it will be observed that there are spans between the columns of from 30 to 45 ft.

The entire structure will be of reinforced concrete on the Coignet system, Mr. Workman, C.E., acting as specialist engineer. On the Wimpole Street face, however, there will be a stone front.

The superload on the ground and first floors is 1 cwt. per ft. super. The other floors and roof are calculated for $\frac{3}{4}$ cwt. per ft. super, and the loading yard is to carry 4 cwt. per ft. super. A most remarkable feature of this building is the considerable spans of the principal beams carrying the first floor, as only four posts are to be provided in the centre of the building.



WESTERN DISTRICT POST OFFICE, LONDON (Plan of first floor).

In order not to diminish the light coming from the inner court it will be necessary to suspend the ends of some of the heavy beams on the various floors to upper beams running between the principal posts above the floor level. These upper beams constitute at the same time the walls of the inner court.

The staircases and landings are to be entirely in reinforced concrete, and also the walls, which will be 6 in. thick, and the various chimney shafts.

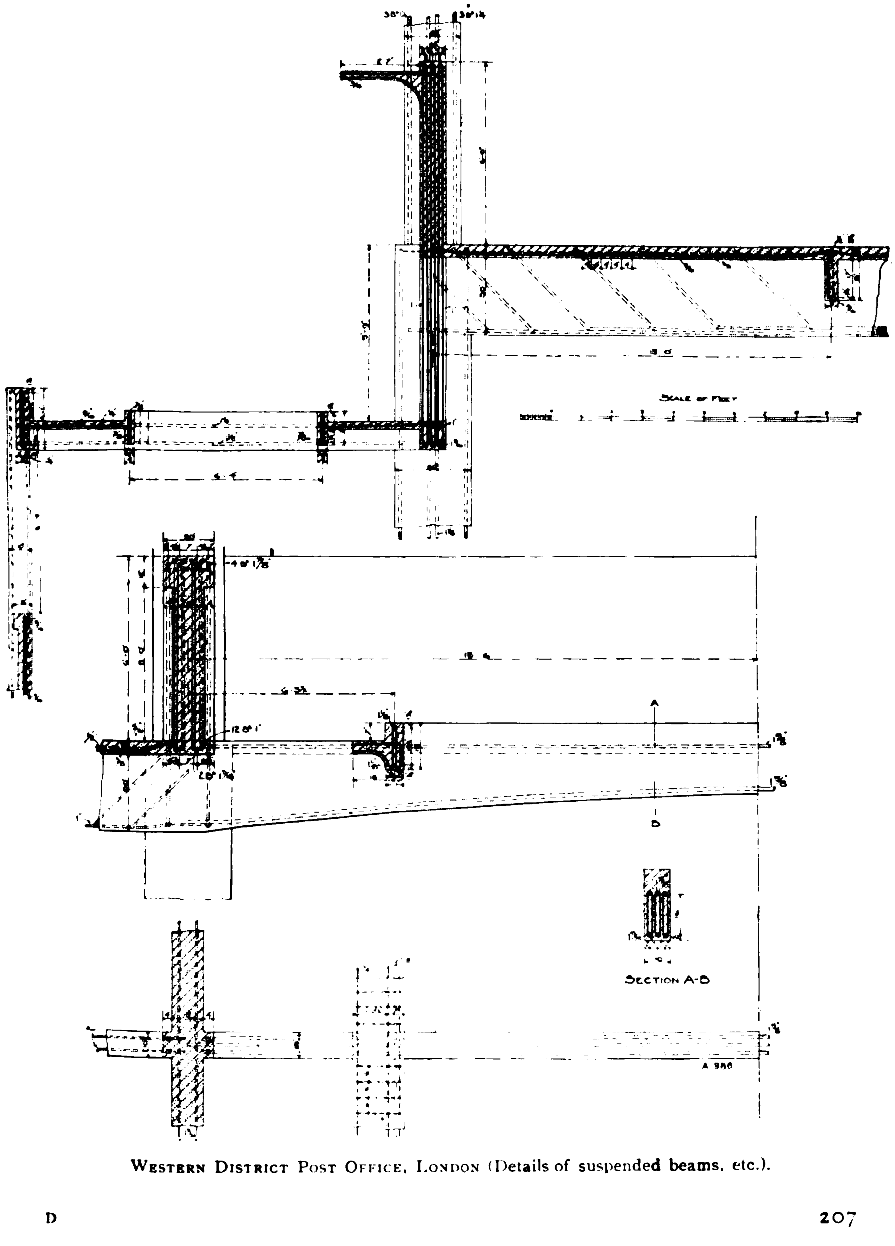
A tank is to be erected in the same material.

In most of the heavy beams the framework is of the trussed type, but in the deep lintel beams, forming also walls or panels, the stirrup type has been used; all angles of posts and beams are to be chamfered.

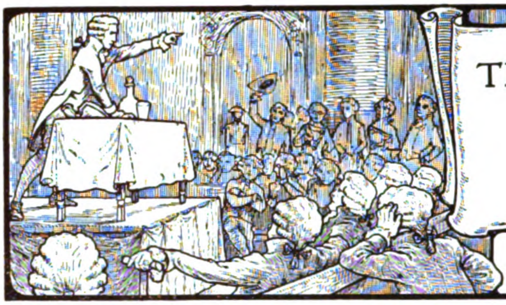
The bearing capacity of the ground is two tons per sq. ft. It will be noticed that a footing or block of ordinary concrete has been placed under each reinforced concrete footing.

The ground is composed of sand and ballast, and has been excavated to a depth of about 9 ft.

The cement used is that known as the "Ferrocrete" brand of The Associated Portland Cement Manufacturers (1900), Ltd.



WESTERN DISTRICT POST OFFICE, LONDON (Details of suspended beams, etc.).



THE INTERNATIONAL CONGRESS OF ARCHITECTS

VIENNA, 1908.

Some particulars will be found below of the International Congress of Architects held at Vienna, together with an important resolution as to records of building accidents generally, and extracts from two interesting papers presented at the Conference.—ED.

PERHAPS the most striking feature of the International Congress of Architects at Vienna for those technically concerned in building construction was the importance attached by representatives of all nations to reinforced concrete.

It was obvious from the many conversations and animated arguments that were taking place on all sides and in all languages that there was a most valuable exchange of experience going on among the members—who numbered over one thousand—as to the best methods of applying reinforced concrete, the difficulties that have to be overcome, the possibility of accidents, and the conditions under which the material could be used economically or the reverse.

It was this personal interchange of opinion and experience that was far more valuable than anything which could be presented in the form of papers or by formal discussion in the lecture room.

There cannot be the least doubt that architects as a body are taking up reinforced concrete for constructional purposes, and that already a considerable number of architects, particularly among the younger generation, are enthusiastic about its practicability and economy.

That reinforced concrete should find numerous admirers in those nations where the scientific education of the architect stands on a high plane is only natural, for it is mainly to those of high technical education that the problems of reinforced concrete most readily appeal. It is for this reason, too, no doubt, that Germany, Austria and France have been the countries in which architects have used this material most, and that it is in those countries that the writings and debates on the subject have been most prolific.

THE ABSENCE OF OFFICIAL BRITISH DELEGATES.

The Vienna Congress was a well-attended one generally speaking, both as far as the official element and the representation of the architects in private practice were concerned. The majority of the principal Governments (with the unfortunate exception of Great Britain) were formally represented, and further, the majority of the leading architectural institutions and societies also sent delegates, with the notable exception of the Royal Institute of British Architects. London architects in private practice were, however, present in fair number, among them Messrs. Ernest George, Leonard Stokes, John Murray, Edwin O. Sachs, Max Clarke, etc., and their presence at least showed that what might have at first sight appeared as a British boycott of the Congress was merely a matter of official blundering and not intentional.

Nevertheless, it might perhaps be well to here immediately intimate that it adds neither to the prestige of Great Britain nor to the prestige of the architectural profession of this country that a Congress such as the Architects' Congress should not have in its midst a Government representative or a duly accredited delegate of its leading architectural society. But maybe the omissions were characteristic of the standing of architecture and of architects as a body in the official and business life of the United Kingdom, for there is scarcely any body of men whose vocation or status professionally, technically and socially is so little recognised by the State as theirs. It would certainly be in the interests of better architecture and more progressive building construction if an effort were made by those who consider themselves the leaders of their profession to improve this state of affairs, which improvement, however, is unlikely until a much broader view is taken by them of the national importance of architecture and the requirements of the profession as a whole.

THE PAPERS.

Turning now to the more formal part of the Congress, we would point out that during one forenoon the subject of reinforced concrete was accorded the careful attention of a large audience, before whom various papers were read dealing respectively with the general position of reinforced concrete in different countries, the possibilities of giving reinforced concrete a suitable architectural treatment, and, further, the most important question of accidents with reinforced concrete and their prevention.

Of the numerous papers presented, extracts from two will be found in translation in these columns—viz., extracts from one by Privy Councillor Launer, of the Prussian Ministry of Public Works, who presented a most useful paper entitled "Accidents in Reinforced Concrete Work and Proposals for their Prevention"; and also from one by Prof. von Emperger, of Vienna (the well-known editor of our contemporary, *Beton und Eisen*), dealing with the present position of reinforced concrete in general terms.

Both papers were valuable contributions to the subject, and the former led to a resolution being taken which may have far-reaching effects if properly acted upon. This resolution read as follows:—

THE CONGRESS RESOLUTION *re* ACCIDENTS ON BUILDING WORKS GENERALLY.

The Congress Resolves—

"That public and municipal authorities should publish official impartial reports on building accidents, so that the true facts of such accidents, classified as far as possible according to the nature of the material, should be at the disposal of those technically interested."

The reason why this resolution should have such far-reaching effects for reinforced concrete is that there cannot be the slightest doubt that if such records are published they will clearly show the extraordinarily small number of accidents occurring in reinforced concrete works, and further they will show that when such accidents do occur they have really nothing to do with the principles of reinforced concrete, but are due in the main to negligence or scamping.

SOME VIEWS.

Originally Herr Launer suggested, we believe, under his Proposal No. 6, the publication of accidents with reinforced concrete only, but it would obviously be unfair to this new form of building construction to pillory such accidents without any similar records being issued of accidents with other forms of construction. This point of view was brought out by Mr. Edwin O. Sachs, who actively participated in the discussion, and led to an interesting three-cornered debate with Privy Councillor Launer and Prof. von Emperger.

It is to be hoped that the Congress resolution as it now stands will be applied in different countries at the earliest possible moment.

We believe that the necessary machinery already exists with us by which such records can be kept and issued in this country under the Factory Acts—*i.e.*, with the Home Office as mouthpiece.

As to Herr Launer's paper, we hold that the suggestions he makes as to the technical education of both the present and coming generations as far as reinforced concrete is concerned, and his idea of training reinforced concrete foremen, deserve the closest attention, while he certainly echoes the feeling of all who have had any real experience of reinforced concrete work when he says that when allotting such work lowness of the tender should not be the determining factor, and that open competition should be avoided.

The importance of Herr Launer's idea as to the skilled supervision of reinforced concrete work can scarcely be adequately realised except by those who have seen the extraordinary manner in which reinforced concrete work is sometimes put together. To name crass instances, we have before us a letter from a gentleman who describes himself as a coal merchant and reinforced concrete specialist, whilst another note-paper heading indicates the writer's vocation as that of an architect and surveyor, estate agent and undertaker! If the writer of the one letter were to execute reinforced concrete work under the supervision of the writer of the other, it would indeed not be surprising if an accident were to occur. Nevertheless it is to be hoped that no such combination of talent will take place, for given an accident, even in such circumstances, the principles underlying reinforced concrete would no doubt be generally blamed by the public press as the cause of the disaster, and no credit given to possible incompetence or negligence in design or execution.

As to the question of responsible contractors, we certainly think that Prof. von Emperger echoes the general view, and the instances he gives of accidents due to incompetence speak more forcibly than any arguments on the subject.

From his paper by-the-bye, we observe that the Professor attaches importance to a careful watch being kept that no inferior cement is brought into the reinforced concrete work, and this, indeed, is a matter requiring rigid supervision, for it is remarkable what efforts are made by unscrupulous or thoughtless contractors to substitute inferior cement for the better brands that comply with the recognised specifications.

As indicated we are giving extracts from both these papers in this issue, and we refer our readers to them.

Other papers of importance were read, and we may have occasion to refer to them in future issues, but speaking generally we hold that the two from which extracts are now published are those which most merit general perusal.

ACCIDENTS ON REINFORCED CONCRETE WORK, AND PROPOSALS FOR THEIR PREVENTION.

EXTRACTS FROM A PAPER

By PRIVY COUNCILLOR LAUNER (**Prussian Ministry of Public Works, Berlin**).

(Free translation from the German.)

THE various advances which have been made in reinforced concrete construction, tending towards a wide-reaching transformation of our methods of construction, have been accompanied by disadvantages which have been a serious set-off against the advantages of the system, and have, unfortunately, given rise to considerable but quite unmerited mistrust.

I refer to the numerous accidents which are known to those who study the subject, some of which accidents have been described in technical periodicals and in the newspapers, and tend to disturb public confidence.

At the beginning of the last century, iron construction, and later on steel frame construction, had to pass through a similar period at a time when the theoretical and practical treatment of metals was not yet common knowledge in the building world, but eventually all prejudice was overcome.

In the same way we shall overcome the present uncertainty in the field of reinforced concrete construction as soon as we have emerged from the stage of preliminary empirical rules and have reached, through the technical experiments and theoretical investigations now in progress in almost every country, to definitive principles.

Insufficient care and supervision all too often go hand in hand with this uncertainty on account of the absence of experience in a new system.

In the interests of public safety we, who hold responsible office, are faced with the task of framing rules which will enable us as far as possible to avoid accidents.

In what follows I will submit some proposals in this direction to your judgment. My proposals take the form of seven definite suggestions, not necessarily for inclusion in official regulations, but certainly as a guide for the policy to be observed if accidents are to be reduced to a minimum.

You will all have observed that certain municipal authorities, architects and building owners, owing to doubts as to the safety of reinforced concrete, show a reluctance to employ it. This reluctance, I believe, is diminishing, but in any case it is to be regretted in the interests of progress.

My suggestions, if carried out, would, I feel convinced, eventually end this reluctance or suspicion with which reinforced concrete is met.

Suggestion No. 1. Technical Education for the Coming Generation.

Instruction in reinforced concrete construction should be obligatory for all students of building construction at trade schools or polytechnics, and in the technical high schools and architectural academies.

In view of the present position of this particular branch of technical training the class work should invariably be supplemented by visits to works in progress and opportunities afforded to attend tests.

The instruction given should be exhaustive without becoming fatiguing or confusing through undue attention being accorded to complex mathematical problems.

Suggestion No. 2. Technical Education of the Present Generation.

For persons holding official positions or entrusted with the supervision of such works (such as district surveyors, borough surveyors, and fire surveyors) who have not had the opportunity of becoming acquainted with reinforced concrete in the course of their studies, facilities should be provided for completing their training in this direction by means of special courses at the technical institutions concerned, attention being primarily given to the lessons of actual practice and the results of experience rather than to theory and calculus.

Suggestion No. 3. The Creation of Reinforced Concrete Foremen.

The provision for training a special class of foreman ("Betonmeister," "Foremen Concreters," as also suggested by Prof. von Emperger) is strongly to be recommended. Evening classes with this special object in view would be welcome.

Suggestion No. 4. Care in Letting Contracts.

In allotting contracts for reinforced concrete work the lowness of the tender should not be the determining factor.

Open competition should be avoided as far as possible.

Limited competition among contractors of standing and experience should be preferred.

Suggestion No. 5. Compulsory Skilled Supervision.

The specifications of contracts should provide for a regular and careful supervision of the work by technically (as distinct from commercially) trained persons.

The local authority should, where feasible, include such provisions as a condition when passing plans or issuing building permits.

Suggestion No. 6. Publicity for Accidents.

The publication of accidents in official organs and gazettes would be particularly serviceable as a warning against reckless and insufficiently trained contractors.

The local authorities concerned in approving and controlling constructional work should be compelled by national legislation to provide for such adequate publication.

Such records would facilitate the recognition of careless or negligent contractors and the correction of any scientific errors discovered in practice.

The publication should be confined to an impartial statement of the facts of the accident, the contractor being named, but criticism avoided as far as possible.

Suggestion No. 7. Prohibition of Incompetent and Unreliable Contractors.

In Germany the law amending industrial regulations (1907) may be very usefully invoked as a check on reckless construction of every description, and thus also of reinforced concrete. By Clause 1 contractors and others may be prohibited from continuing the practice of a trade or of a special department of it in case of their incompetence being proved. By Clause 3 the execution and supervision of a building may be refused to an individual if the local authority concerned should determine that the practical experience or technical training of that person is insufficient, or that his untrustworthiness renders him unsuitable.

This law provides the most efficient means of what I might term the " purifying " of the building trade in general, and the reinforced concrete trade in particular, from negligent, incompetent and greedy individuals in the interests of public safety and general welfare, and legislation on not dissimilar lines might be beneficially introduced in other countries.*

A REVIEW OF THE PRESENT POSITION OF REINFORCED CONCRETE GENERALLY.

EXTRACTS FROM A PAPER

By PROFESSOR FRANZ VON EMPERGER (Vienna).

(Free translation from the German.)

There are four main questions before architects to-day, when they consider the advisability of using reinforced concrete :

I. Its economy.
II. Its utility and its practice (involving the question of contractors).
III. Its resistance against fire, rust, wet, shock, earthquakes, etc.
IV. Its architectural rendering.

Economy of Reinforced Concrete.

We place economy first, even in an assembly of architects, many of whom profess to be artists. The superior economy of reinforced concrete was the leading motive of its introduction, and has been the main cause of its success.

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* The lecturer might also have pointed to the German law against unfair competition, under which the Public Prosecutor steps in where orders or contracts are obtained by the statement of incorrect facts, such mis-statements being of serious import where the safety of life for human beings is concerned.—ED.

With reinforced concrete it is possible to obtain somewhat better results than with the common methods of construction, and that at less expense.

Its economy, when properly applied and for appropriate purposes, is undisputed.

The Utility of Reinforced Concrete.

Reinforced concrete can also nowadays be recommended on the ground of quality independently of price.

If proof of this were still wanted I am able to lay before you innumerable valuable communications dealing with this subject, and examples of infinite number.

As regards the much discussed failures or accidents with reinforced concrete, these incidents are generally due to a combination of causes, but the principal causes of the accidents may be stated to be the following:—

> Negligence in workmanship or materials; insufficient dimensions or insufficient provision against shear in the design; or the settling of the foundations.

The Practice of Reinforced Concrete.

The practice of reinforced concrete construction is a new one, and when we look into the history of other methods of building we shall find that on all important questions accidents were the principal teachers. This was the case both with brick or stone vaulting, and with steel frame construction before they reached the present standard of completeness.

This process of learning, based on the lessons of failures, may be observed not only in the history of each department of building, but in the lifetime of each individual in the profession or trades concerned, for it is experience that teaches.

Reinforced concrete is no exception to the rule, and the number of collapses that have occurred, as a matter of fact, are very small.

The cause of the comparatively small number of accidents is that reinforced concrete generally furnishes its own danger signals, and as a matter of fact danger is only generally met with where design and execution do not go hand in hand, as is especially the case with work by firms who design the building but leave the execution with entire strangers. The latter—*i.e.*, the strangers—are often technically inexperienced contractors. Fortunately, however, this system is now dying out in most countries. The disadvantage of having the entire stranger as contractor is, however, frequently discounted by the advantage of having the designs prepared by a central specialist designer of high standing and great experience.

Nowadays quite small firms often attempt to act simultaneously as designers and contractors of reinforced concrete. Insufficient knowledge is thus often combined with limited experience and accidents follow almost as a matter of course.

Some accidents due to bad design and bad workmanship can be checked by legislative means. In proof of this it need only be remembered that the Latin countries and North America—*i.e.*, territories in which comparatively the greatest legal freedom prevails in building matters—record the greatest number of serious accidents. Countries in which plans of buildings are carefully examined by the public authorities and the supervision of the work by the authorities is honest and painstaking, are practically free from serious accidents.

Responsible Contractors.

But more important than all regulations should be the responsibility in common law of the contractor for all accidents on a building. Such responsibility should prevent inexperienced persons from trying to make undue profits by undertaking such works, careless of the consequences to their fellow-men.

Of the manifold possibilities of this effort of inexperienced men to make profits the following are mere instances of accidents from my personal experience:—

1.—The construction of a truss on a very flat roof without taking account of the thrust on the outer walls.

2.—The anchoring of a horizontal roof-tie into the external walls without sufficient regard to the nature of those walls.

NOTE.—Whilst in the first case mentioned the wall was thrust outwards, in the second, which ended in a collapse, the wall was pulled inwards.

3.—The construction of continuous beams over supports of different material, such as over poor lime mortar brickwork and reinforced concrete columns.

4.—Various defects in the reinforcement, such as the entire omission of stirrups, insufficient tension rods, etc.

5.—Subsequent changes of design, such as the introduction of skylights, almost completely destroying resistance to compression.

6.—Improper repairs.

All such possibilities, and they are mere instances, make it desirable that reinforced concrete work should be carried out by firms, which on the one hand are not too extensive in their operations, and on the other not too small. Moderate-sized firms will obtain fair remuneration, and should please all concerned. The very large or the very small firms alone can afford that class of competition for work which leads to reckless cutting of prices, and to scamping in execution. Good work can, as a rule, only be expected from well organised and experienced firms of moderate size where the personal element of the management is a factor in the interests of careful design and well directed execution.

Portland Cement and Reinforced Concrete.

It is necessary that the contractor should be familiar practically and experimentally with the properties of Portland cement, and that only the very best qualities of Portland cement should be employed on reinforced concrete work.

It should be the task of the supervising architect to ensure, by a control of the plans and materials and a frequent examination of the execution, that the concrete contractor is fulfilling his duties satisfactorily, and particularly he should keep a careful watch that no inferior cement is brought into the work.

Resistance against Fire, etc.

With what lack of understanding and prejudice the advantages of reinforced concrete have yet to reckon is shown by a recent fire in Vienna, when a building constructed with unprotected cast-iron columns, unprotected joists, some vaulting and a reinforced concrete roof only, collapsed completely. Immediately every newspaper quoted the fire as the best proof that reinforced concrete would not resist fire.

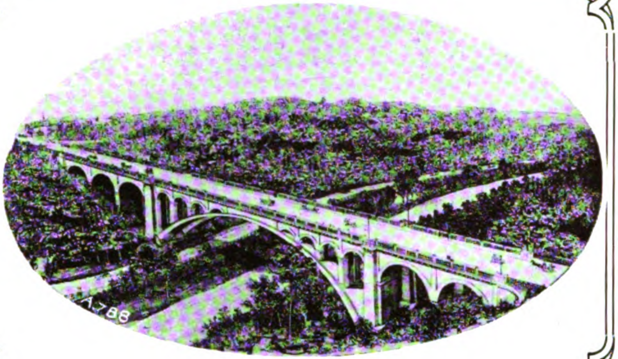
Reinforced concrete when properly designed and executed to fulfil the purposes of a fire-resisting material is our best known means of constructing a "fireproof" building, only, naturally, like other materials, it must be employed with a proper understanding of the purpose to which it is put. Similarly it resists most satisfactorily the other disturbing influences of nature, such as rust, shock, etc., if ordinary safeguards are provided for, but the obvious premise, as in every form of building construction, is care.

The Architectural Rendering of Reinforced Concrete.

Those who remember the difficulties with which the architectural rendering of steel framing had, and still has, to contend, will rejoice that the attempts of architects in this matter of the treatment of reinforced concrete have generally been successful.

I think I am right in assigning this to the fact that concrete is a material which, especially in combination with steel, gives the architect the greatest freedom. I feel no doubt this question of architectural rendering, the solution of which is reserved for architects, will be greatly advanced by this Congress, and that the best means of attaining that end is a free exchange of ideas between different nations.

THE WALNUT LANE CONCRETE BRIDGE, PHILADELPHIA, U.S.A.



So much is being considered at the moment in connection with reinforced concrete, that the interesting problems arising out of simple concrete and concrete in block form are almost being overlooked.

It is for this reason that we are from time to time publishing notable examples of plain concrete work, and no better instances could be given than those of the Connecticut Avenue Bridge, Washington, which we dealt with in our issue of September, 1907, and the example we are now presenting of the great Walnut Lane Bridge at Philadelphia. As examples of concrete block construction we hold both to be among the most perfect in the world, well designed and most carefully executed.

The description we publish consists in the main of illustrations taken from the working drawings accompanied by photographs of the bridge in course of construction. These, with some notes which, without any claim to literary veneer, state the facts, and present in extract form points of importance from the working specification, we are indebted for to Mr. George S. Webster, M.Am.Soc.C.E., Chief Engineer to the Department of Public Works, Philadelphia (who designed the bridge in conjunction with Mr. Henry H. Quimby, M.Am.Soc.C.E., Assistant Engineer), and who has kindly placed the material at our disposal.—ED.

THE bridge that is being constructed by the city on the line of Walnut Lane, across the Wissahickon Creek and ravine, is progressing rapidly, has now reached a stage that makes it interesting to the miscellaneous public as well as to engineers.

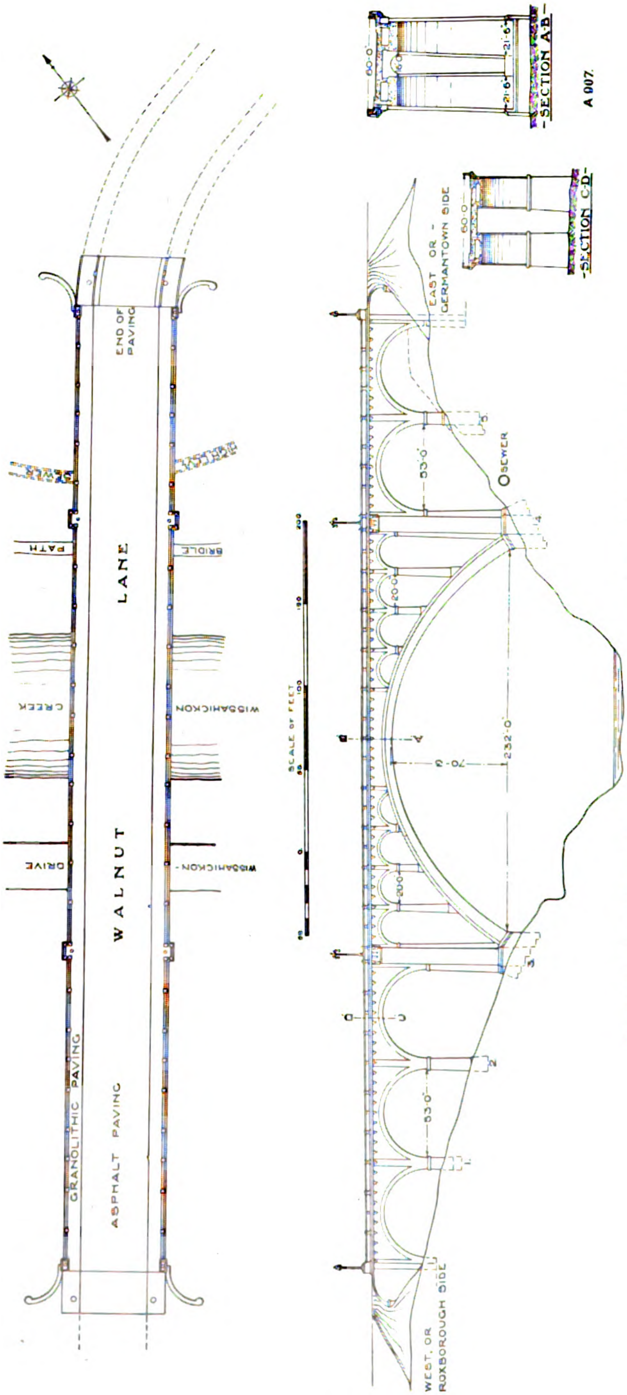
This structure will provide a direct line of travel with easy grades between two populous sections of the city—Germantown and Roxborough—where heretofore traffic was required to make long detours over very heavy grades. The steepest grade of approach to the bridge will be 4½ ft. per hundred, descending from Germantown. The grade on the bridge in the same direction is 1½ ft. per hundred, continuing to the present grade of Walnut Lane in Roxborough.

Besides being a valuable addition to the city's public utilities, the bridge will constitute a magnificent monument of architectural beauty and engineering achievement. It embraces a notable arch of majestic proportions that is already attracting the attention of the engineering profession abroad because of its great size and height and the novelty of the method of its construction.

The whole structure is of concrete, and with a surface finish resembling stone in colour and texture and wearing qualities. Such steel as is used is deeply embedded in the concrete, and therefore no metal will anywhere be exposed to view or the elements and no painting will ever be required.

The parapets along the sidewalks will be concrete balustrades of classic design.

The driveway will be 40 ft. wide in the clear between the kerbs, affording ample driving space outside of the street car tracks, a double line of tracks being provided for. The two sidewalks are each 8 ft. wide without any obstructions along the kerbs in the shape of trolley or electric light poles.

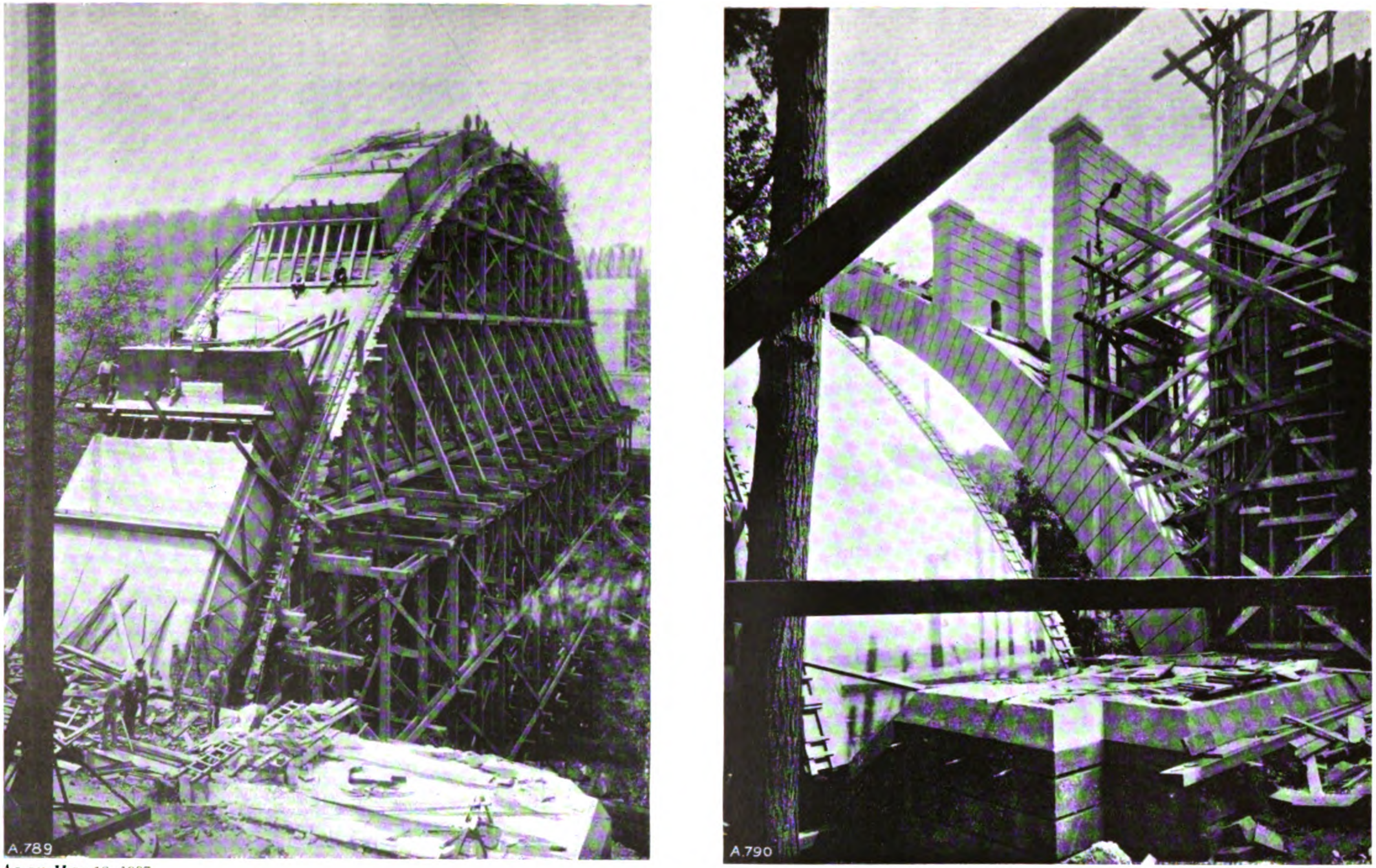


THE WALNUT LANE CONCRETE BRIDGE, PHILADELPHIA (general plan and sections).

The deck of the bridge will be 147 ft. above the creek, higher than the tallest trees in the valley, and it will, therefore give a grand view both up and down the valley and across Roxborough, and will no doubt become popular for both driving and walking.

The main arch is 233 ft. clear span between the piers, reaching from the rocky bluffs high above the creek on the east slope to a point back of and above the drive on the west side, permitting ample widening of the drive in the future. The under side of the arch is 133 ft. above the creek and 101 ft. higher than the surface of the Wissahickon drive. The springing point of the arch at the face of the piers is 34 ft. above the drive.

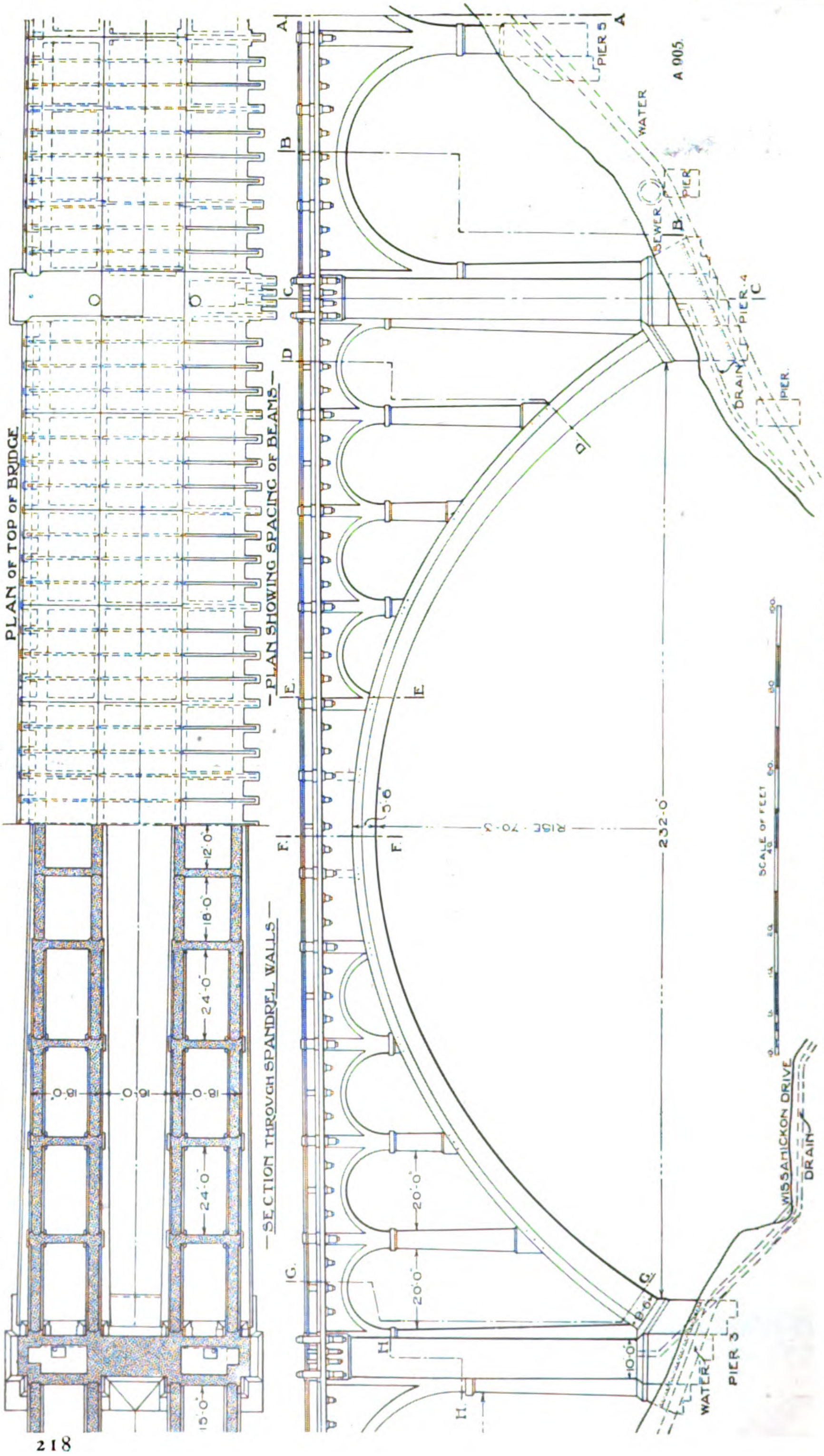
The general plan of the structure is that of twin supporting arch ribs floored across on top, and this scheme is carried throughout the five approach arch as well as the main arch. This plan secures economy as well as lightness. Over each main arch rib the floor is carried on eight pairs of spandrel or relieving arches, which carry the four longitudinal walls upon which the floor will rest. The whole will be hollow under-



As on May 18, 1907.

As on Sept 11, 1907.

THE WALNUT LANE CONCRETE BRIDGE, PHILADELPHIA (Views in course of construction).

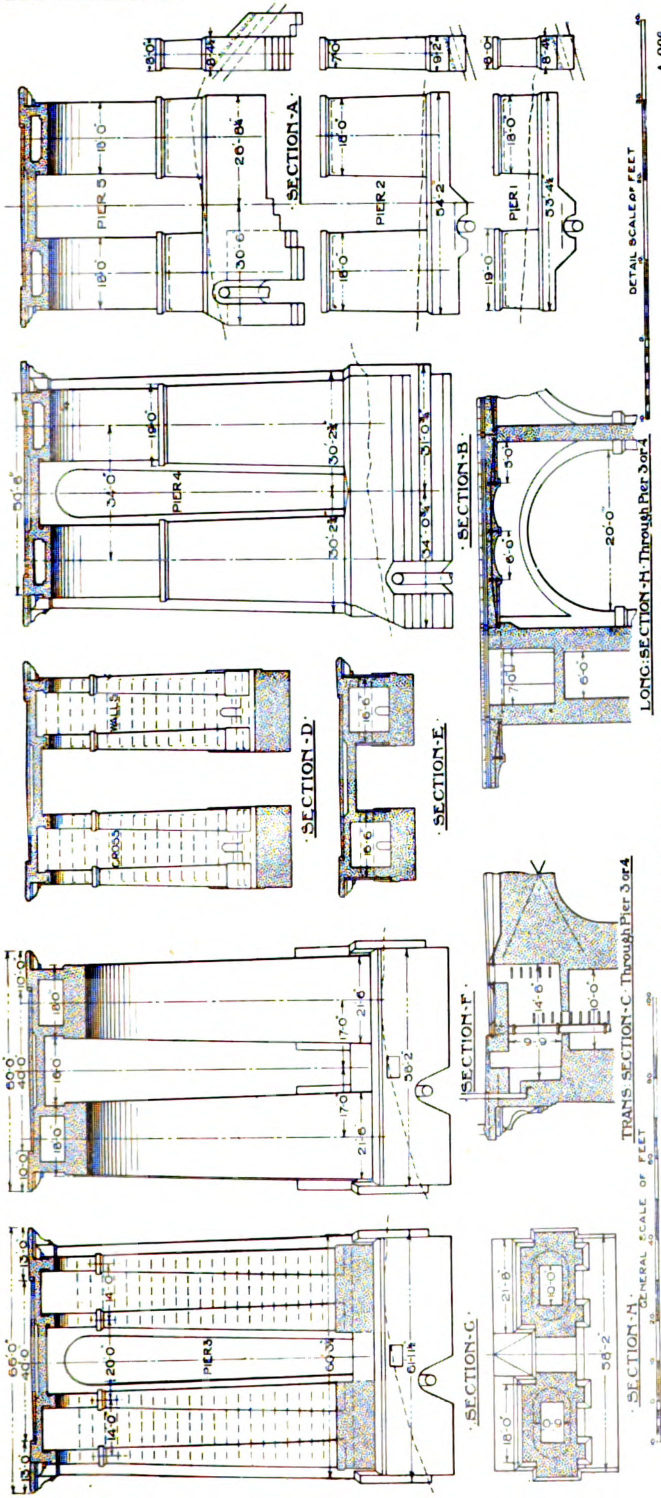


The Walnut Lane Concrete Bridge, Philadelphia (plan and details of main arch).

neath clear up to the floor, and consequently no earth filling is required, thus effecting great saving in weight and required strength.

The five approach spans, while small in comparison with the main arch, are of a size that not very many years ago would have been considered large. They are each 53 ft. clear between the piers, and those next to the main span are about 70 ft. clear above the ground. It is hoped to have the bridge completed this year.

The following are extracts from the contract specification:—



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THE WALNUT LANE CONCRETE BRIDGE, PHILADELPHIA (general sections).

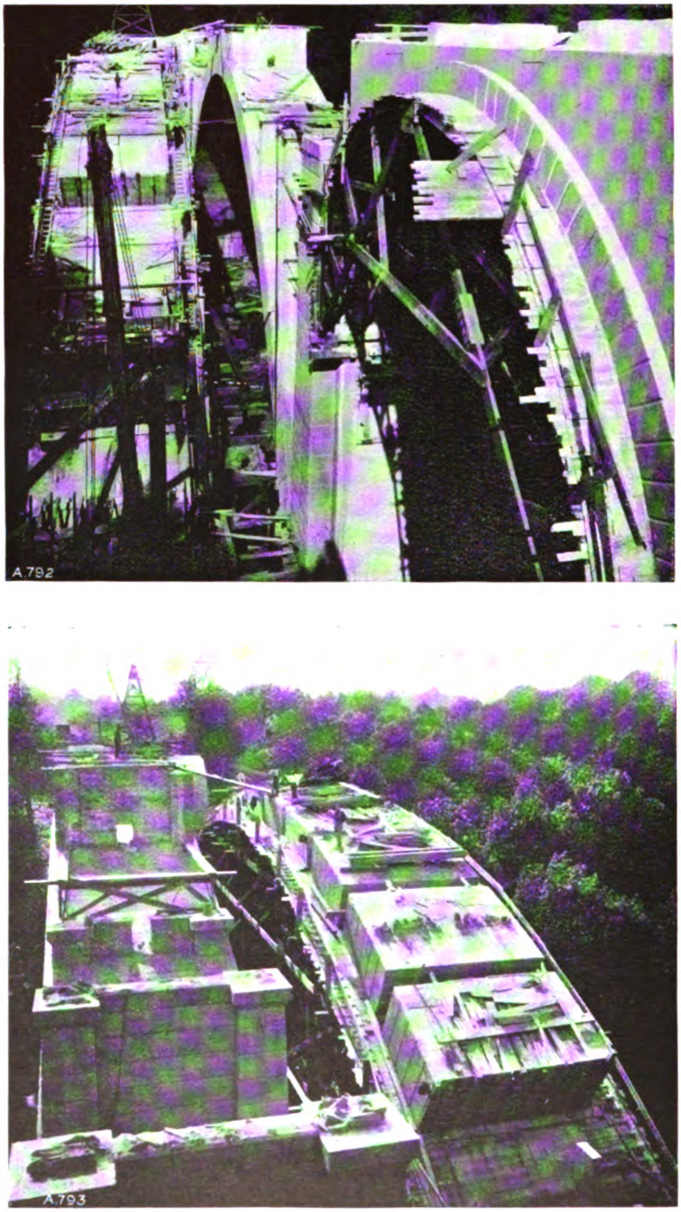
GENERAL DETAILS OF CONCRETE WORK.

In all foundations, stones of derrick size may be embedded, and smaller stones may be embedded with them, but they shall not be closer than 2 in. to any face, and they shall be used only by depositing concrete first and joggling the stones down into it. The embedded stones in the foundations of piers 3 and 4 shall be of flat shape, and as far as practicable inclined so as to be normal to the direction of the resultant thrust on the pier.

The concrete of the main arch ring shall be composed of 1 part cement, 2 parts coarse sand or gravel, and 5 parts crushed stone, with embedded flat stones. The crushed stone shall be from $\frac{1}{4}$ in. to $\frac{3}{4}$ in. in size and thoroughly mixed. The embedded stones shall be not less than one-man size, and of such shape that their thickness will be approximately one quarter of the average dimension, and shall be of quality and character equal to the best of Conshohocken stone and be approved as such. They shall be placed in radial planes as close together as practicable, always edgewise to the centering, and embedded by first placing a sufficient depth of concrete and then working the stones into it. At the points of bearing of the spandrel piers and of the spandrel walls a number of these stones shall project above the arch ring to form a footing and bond. The concrete of the 20 ft. spandrel arches and the 53 ft. approach arches shall be of the same composition with similar stones of same character and of suitably proportioned size similarly embedded.

All vertical walls of neat work shall have embedded in the concrete approved hard stones of cubical shape not less than one-man size, so that they approach not closer than 2 in. to any surface, and so that every course or layer will have a number of the stones projecting up from it to dowel or bond with the succeeding course.

The concrete of the sidewalk brackets, of the floor, and of the balustrade shall be without embedded stones, except that suitable cubical stones from 3 in. to 6 in. in any dimension shall be embedded in the top of brackets to dowel with the coping, and in the top of the coping to dowel with the base of the balustrade.



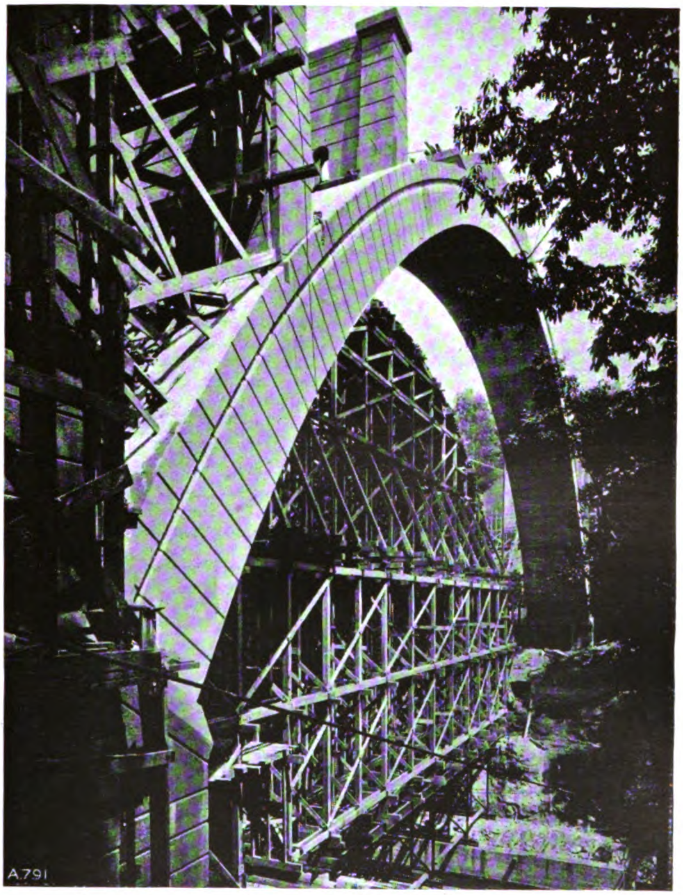
THE WALNUT LANE CONCRETE BRIDGE, PHILADELPHIA (in course of construction).

Piers 3 and 4 must be complete to and including the skew backs at least one month before the concrete of the main arch is deposited.

Each main arch ring shall be constructed in transverse sections in pairs—opposite sides simultaneously—to ensure symmetrical load on the centering. These sections shall be of such length that each pair can be constructed in daylight of one day. A detail plan showing the sections and the required order of construction will be furnished by the City. The sections shall be separated by spaces of about 2 ft. 6 in. which will constitute the keys of the arch. The keys shall be constructed not earlier than two weeks after the last pair of sections has been placed. The lower four key spaces on each side shall each have on the mid line three concrete piers 12 in. by 18 in., constructed at the same time as the sections, to maintain the separation of the sections and prevent possible sliding on the lagging. These piers will be surrounded and built in by the placing of the concrete of the key. The joints between keys and sections shall be locked by tongue and groove 1 in. deep.

The design of the centering to be used shall be submitted for approval before proceeding with its construction. The falsework for the arches shall rest on rock or on masonry piers built on the rock. The design shall be such as to avoid, so far as practicable, bearing across the fibre of wood, confining the pressure as far as possible to end fibre in order to reduce to a minimum the yielding of the structure as it receives the load. Means shall be provided for lowering the supports evenly and gradually under absolute control.

Expansion joints in walls and all joints in balustrade shall be locked by tongue and groove 2 in. deep, and have $\frac{1}{8}$ in. thickness of asbestos felt separating the surfaces. Expansion joints in the floor shall have $\frac{1}{2}$ in. thickness of asphalt mastic. The balustrade joints occurring at floor joints shall have $\frac{1}{4}$ in. of asbestos felt and have the locking tongue only slightly bevelled to permit free movement.



Walnut Lane Bridge (main arch in course of construction).
(*As on September* 11*th*, 1907).

At expansion joints in floor where movement involves sliding of the floor slabs on the walls the bearing of the sliding portion shall consist of a strip of $\frac{1}{16}$ in. thick sheet zinc of the width of the bearing, flanged up 1 in. at the back edge. Under the paving over the openings a strip of sheet zinc 6 in. by $\frac{1}{8}$ in. shall be laid as an apron to retain the asphalt.

At expansion joints in the sidewalks the electrical conduit pipes shall be jointed by wrapping each with 4 in. by $\frac{1}{32}$ in. zinc to permit movement.

The connection between the 15-in. beams and the 20-in. beams of the floor must be made with taper turned bolts. The connecting angle is to be riveted to the web of the 15-in. beam with four $\frac{5}{8}$ in. rivets and the holes in the flange of the 20-in. beam are to be drilled in position and reamed taper to fit the bolts which shall be not less than $\frac{7}{8}$ in. diameter at the point of shear.

There shall be embedded in the concrete around the bottom flange of each floor beam $\frac{3}{16}$ in. wire loops 3 in. apart, connected on each side of beam above the flange by two longitudinal wires ⅛ in. diameter 3 in. apart to hold the loop in position. There shall be no longitudinal connection below the flange. The longitudinal wires shall be secured to the loops either by welding as in the "Clinton Wire Cloth," or by tightly wrapping as in the "Wight Lock Woven Steel Fabric."

CEMENT CONCRETE.

Proportions.—Cement concrete unless otherwise specified shall be composed of 1 part cement, 3 parts coarse sand or gravel, and 6 parts crushed stone. These proportions shall be determined by measurement, a barrel of cement being taken to contain 3·6 cu. ft., and a bag of cement ·9 cu. ft.

Sand or Gravel.—The sand or gravel shall consist of grains graded from coarse to fine, not exceeding one-quarter of an inch in diameter, containing not more than 5 per cent. by weight of loam, clay, dirt, and other impurities, and be equal in quality to the best New Jersey bank sand or gravel.

Crushed Stone.—The stone shall be clean, hard crushed stone or pebbles to be approved by the Chief Engineer, comprising the whole run of the crusher from ¼ in. to ¾ in. in size when used for bedding on metal decks or for balustrades and parapets, and from ¼ in. to 2 in. for other purposes, screened of dust and particles less than ¼ in.

Storage piles of material shall be on a platform or other hard clean surface to avoid admixture of dirt.

Mixing.—When mixed by hand, the cement and sand shall be first mixed dry and then made into mortar. The stone shall be spread upon a suitable floor to a depth of about 6 in. and thoroughly wetted, and the mortar evenly spread over it, care being taken that the stone of each batch is mixed as to size. The whole mass shall then be turned over four times and raked to secure complete and uniform mixture. If the contractor desires to use some other method he must submit it for approval. Concrete shall be kept in motion until deposited in place. Should any be permitted to set before placing or tamping it shall be removed and not used. Hand-mixed batches shall not be larger than 1 cu. yd. in volume.

Preparation of Surfaces.—Surfaces upon which concrete is to be deposited, whether of old masonry or of concrete layers, shall be thoroughly cleaned and wetted and coated with a thin but complete layer of cement mortar.

When concrete is marked on the face into courses, each requiring two or more layers, the layers shall follow each other in close succession before setting so as to avoid visible joints in the face of a course.

Depositing.—Concrete shall be deposited in layers not more than 6 in. in depth, and compacted by tamping until flushed. When used for foundations it shall, when practicable, be deposited and rammed against the sides of the excavation. In the abutments of arches the layers shall be sloped as nearly as possible normal to the direction of the line of thrust of the arch.

Joints.—In work above ground the top surface of each course shall be scraped within 24 hours to remove the "laitance" or scum, and ensure the adhesion of the next layer.

Embedded Stones.—In foundation concrete approved hard stone of one-man size or larger may be embedded in the concrete, the stones to be separated sufficiently to be each completely encircled by the concrete, and to be not closer than 6 in. to any face of the foundation. In neat work similar stones but not larger than two-man size shall be embedded in each course so as to project up and form dowels bonding the courses together.

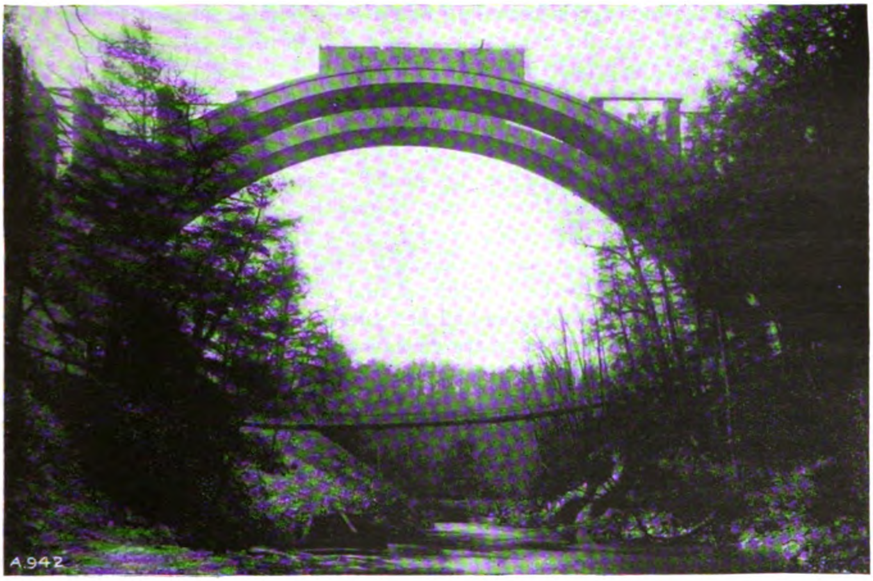
Protection.—Finished concrete work shall be protected until thoroughly hardened, against disturbance, by preventing working or building upon it, and against the sun, if necessary, by covering and wetting for at least 48 hours.

WALNUT LANE BRIDGE (View of main arch from the valley).

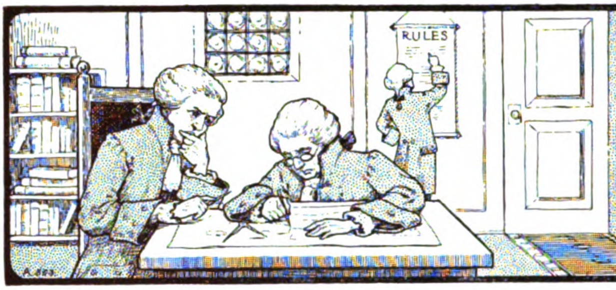
Waterproofing.—When asphalt is to be used for waterproofing concrete work, the surface of the concrete shall be painted completely with the asphalt paint described in Paragraph 121 before applying the asphalt mixture. Expansion joints in retaining or spandrel walls, and joints in arch rings shall be protected against the infiltration of water by applying over them a strip 12 in. wide of "Hydrex" waterproofing or other substance to be approved as equal.

GRANOLITHIC SURFACES.

Granolithic surfacing, when required, shall be composed of 1 part cement, 2 parts coarse sand or gravel, and 2 parts granolithic grit, made into a stiff mortar. Granolithic grit shall be granite or trap rock crushed to pass a ¼-in. sieve and screened of dust. For vertical surfaces the mixture shall be deposited against the face forms to a least thickness of 1 in. by skilled workmen as the placing of the concrete proceeds and thus form a part of the body of the work. Care must be taken to prevent the occurrence of air spaces or voids in the surface. The face forms shall be removed as soon as the concrete has sufficiently hardened, and any voids that may appear shall be filled with the mixture. The surface shall then be immediately washed with water until the grit is exposed and rinsed clean, and protected from the sun and kept moist for three days. For bridge seat courses and other horizontal surfaces the granolithic mixture shall be deposited on the concrete to a least thickness of 1½ in. immediately after the concrete has been tamped and before it has set, and shall be trowelled to an even surface, and after it has set sufficiently hard shall be washed until the grit is exposed.



THE WALNUT LANE CONCRETE BRIDGE, PHILADELPHIA
(*The* 233 *ft. span as on March 27th*, 1908).



Concrete Block-Making in Great Britain.

PART I.

By H. KEMPTON DYSON, C.E.

Although the United States, in particular, has been making great headway of late in the production and use of concrete blocks, both solid and hollow, progress in Great Britain has been somewhat slow in this direction, and we have thus pleasure in presenting some particulars as to the industry in this country in the form of a series of articles dealing with the subject both, historically, as far as patents call for notice, and practically, as far as modern practice and experience are concerned.—ED.

THE use of concrete blocks for the erection of buildings has been growing in favour of recent years, and the industry is becoming one of considerable magnitude and importance. In the United States the industry is older and is of much greater dimension, but it seems probable that the proportion of work done in this country with concrete blocks will be as great as that in America in a short while. The chief reason for the slowness of development of a system of building that was invented many years ago is to be attributed to the absurd restrictions placed by the by-laws upon the erection of concrete walls. These by-laws, founded upon the model issued by the Local Government Board, generally require walls of concrete to be one-third thicker than those of brick, no allowance being made for the much greater strength of concrete walls composed of good materials. The regulation was obviously framed for poor concrete, whereas the quality of material should have been regulated and latitude allowed for the reduction of thickness in walls if good materials had been used. The Local Government Board has, however, within the past few years endeavoured to effect a reform in these matters, and before many years have passed there is no doubt the erection of frame buildings, in which the loads are carried upon piers, stanchions, or framing, and the walls become mere panels filling between, will be generally permitted in urban as well as in rural districts.

The first use of concrete blocks for the building of walls in this country cannot be accurately determined, nor for the matter of that can we settle the date of the earliest example of concrete block making in the United States or abroad.

Not much in the way of concrete-block work could be expected until the invention of Portland cement, although we have the instance of Roman aqueducts existing in Spain, built of large moulded blocks of lime concrete, apparently cast independently and erected in the form of masonry. The hollow block is of comparatively recent invention, but we see by this that solid concrete blocks were known to those great builders in concrete, the Romans.

With regard to the making of concrete blocks for the erection of buildings, there seems to have been running in the minds of inventors two influences :—

1. The idea of imitating masonry construction, and
2. The moulding of substitutes for bricks of clay.

It is the masonry aspect which first led to the invention of solid blocks of concrete in the form of blocks of stone which could be built in walls as masonry.

A great amount of business has been done for many years past in the making of artificial stone, which belongs to the first category. The modern concrete-block industry, however, is more allied to the second class, and it has only been developed in comparatively the last few years, although the efforts of inventors were early led in this direction by a knowledge of the process of working clay in the form of hollow bricks or blocks. That these two influences have been the primary reasons for inventors' minds running in these directions is evident in the earlier patent specifications, in which the solid blocks are referred to as imitating masonry, whereas the hollow forms are referred to as bricks or blocks. We are concerned with both aspects, but more especially with the second, because there are inherent advantages in this form of construction which have brought it into more general adoption.

The records of the Patent Office furnish us with some early history regarding the use of concrete blocks. The earliest suggestion of such building materials is contained in a patent granted to Thomas Grant, dated July 20th, 1632. At this date no description of the inventor's methods was published. This particular patent deals with a number of things (magic glasses, for instance), but the interesting reference that suggests that Thomas Grant made concrete blocks is contained in the title, and runs as follows :—

> " A Building Moulde or Stone Press, very requisite for the Building of Churches or Greate Houses, by which Stone Windowes, Door Cases, Chimney Peeces, &c., are made more Speedily without Hewing, Cutting, Sawing, Carveing, on Ingraveing, as also Bricks and Tiles more Beautiful to the Eye and more Dureable against Foule Weather, Being as Smooth as Glasse on the one Side or End with Divars Colours and Workes as if they were Carved by Skilful Handes and Curious Workmanshippe."

The first patent, so far as we can trace, that really deals with the making of concrete blocks for the erection of walls from a modern aspect, is that by Mr. John Francis Wyatt, an engineer, of London, taken out in 1814. This belongs to the solid block class, which seems to have first exercised the attention of inventors as a substitute for masonry. We reproduce the drawings (*Figs.* 1 and 2) from Wyatt's specification, which was entitled :

> " New Kinds of Bricks or Blocks, One of which is particularly adapted for the Fronts of Houses and other Buildings, giving to them the Appearance of Stone; Another is applicable to a new Method of Bonding Brickwork; also a new Kind of Blocks or Slabs for Paving Floors and Facing or Lining Walls, instead of Ashlar, which will resemble Marble or Stone, and which may be applied to Steps, Stairs and other Parts of Buildings."

The following is his specification :—

I prepare thin pieces, plates, or slabs of stone, of sizes to fit the sides and ends of the bricks, or blocks, or masses, or lumps intended to be used in the fronts of buildings. These pieces, plates, or slabs, being previously cleaned and wetted, are then placed in moulds and Parker's cement, or what is more commonly known by the name of Roman cement, or any other proper cement in a fit state of moisture, is laid upon them, and which is to remain till the cement be sufficiently indurated and united to the stone, or the cement may first be put into the moulds, and the pieces, plates, or slabs of stone laid upon it, and remain till the cement be sufficiently indurated and united to the stone. They are then to be taken out of the moulds, and piled up or placed in a proper situation for drying; the longer they are exposed to the atmosphere, the harder they will become, and in a few months or a shorter period they will be hard enough for use without the application of artificial heat. The pieces, plates, or slabs of stone need not be more than half an inch thick, but may be thicker or thinner according to the discretion of those interested in the work. The quality of the stone to be used for the pieces, plates, or slabs is best if somewhat bibulous or porous, and for this reason I prefer Bath stone, but Portland or even marble may be applied, if the cement be such as will cohere to the stone or marble, although I recommend for the purposes of this Invention the cement prepared according to James Parker's Patent, dated One thousand seven hundred and ninety-six; any other cement possessing the property of becoming so indurated in a short space of time is proper for the purpose. It is not necessary to use Parker's or any other cement without the admixture of any other materials; on the contrary it will be advantageous in many cases to mix with it clean, rough sand, small gravel, fragments of bricks, flint stones, shingle, scoria of iron, copper, slag, and other such materials, taking care that the proportions of Parker's or other proper cement be sufficient to make a strong union with the pieces, plates, or slabs of stone or marble and the other materials. The moulds I use in making these bricks or blocks, or masses, or lumps, I do not consider as a part of the Invention; those used in making bricks in the common way will answer the purpose, only the bricks, or blocks, or masses, or lumps must remain longer in them to become indurated, than is used in the common way of brick making. For binding brickwork I make protuberances on the upper side of each brick, or block, or mass, or lump, so that such protuberances shall nearly fit or fill the hollow left in the under part of the brick, or block, or mass, or lump, on which it is to rest, and when walls are to be built exceeding nine inches in thickness, I build two thin walls, either brick, on edge, or otherwise parallel to each other, and fill up the intermediate space with a composition of cement, sand, rubble, or such like materials, thereby connecting and bonding the two walls together, as represented in the section of the wall, *Fig.* 1. For facing or lining walls only, the inner wall may be built with bricks, or blocks, or masses, or lumps, and the outside or external one may be real or artificial stone, as represented at A, A, at the section *Fig.* 2. Paving blocks or slabs are made in the same manner as the faced bricks, or blocks, or masses, or lumps, either by laying the thin pieces, plates, or slabs of stone or marble at the bottom of the mould, and applying the cement or composition upon them in a proper state of moisture, or by putting the cement or composition into the mould first, and placing the stone or marble upon it, and left till sufficiently indurated before taken out. These blocks or slabs may be either entirely or partially faced with bibulous stone or even marble, and when partially faced, they may be laid in ornamental figures, or the stone may be first laid, or the blocks or slabs separately shaped and prepared, and the design engraved upon the surface and under cut, and the cement trowelled into those parts, or the stone parts of the pavement may be laid in their intended situations on the floor with a sufficient cement underneath to raise them all to a level surface, and the spaces between them afterwards filled up with cement to the surface of the stone, and when sufficiently indurated, rubbed down to a smooth surface by any of the usual methods. The steps or stairs are made in the same manner as the bricks, or blocks, or masses, or lumps.

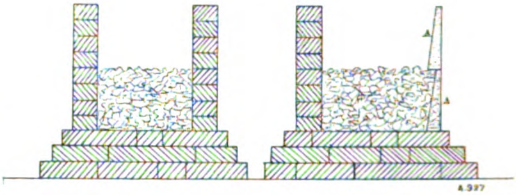


FIG. 1. FIG. 2.

DRAWINGS FROM WYATT'S 1814 PATENT SPECIFICATION.

It will be seen from this that Wyatt contemplated the use of concrete of a kind, but not of the kind we instinctively associate with the name. He proposed using pieces of stone or brick, or even old bricks cemented together.

There is another early inventor—a Wm. Atkinson, who took out a patent in 1816—who worked on similar lines, using bricks, which he bedded in lime mortar in a mould, and afterwards plastered so as to form large stuccoed ashlar blocks—*i.e.*, artificial stone. Wyatt, however, should be called the inventor of concrete blocks, and his form of facing block, triangular in section (*Fig.* 2), is the precursor of the **L**-shaped facing blocks, which we shall find other inventors patenting at a later date. We have no information as to what extent this form of construction, or that of Atkinson, was used.

As regards early invention in the direction of artificial stone, in the general aspect this does not interest us so much as the particular application to the erection of walls with concrete blocks of a handy size. We may, however, refer to the patent taken out by a John Kent in 1810, which describes how artificial stone may be made with a concrete composed of one part powdered quick-lime mixed with three parts of sand, and then afterwards mixed still further with another six parts of coarse sand or gravel. It was directed that this concrete should be rammed into moulds.

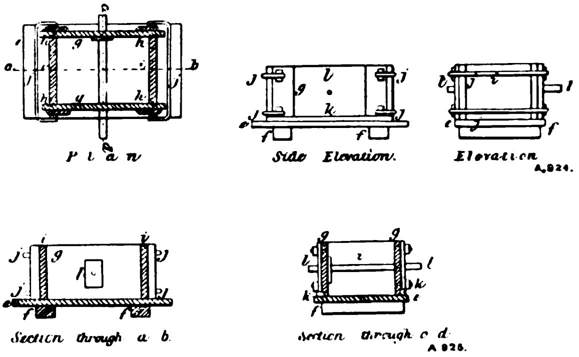
We next come to the year 1832, when Mr. Wm. Ranger, a Brighton builder, took out a patent for what he termed "Ranger's Artificial Stone." The use of concrete blocks in any extensive way, and in a systematic manner, begins with Ranger, so far as we can learn. His invention gained some notoriety from the fact that the walls of the College of Surgeons in Lincoln's Inn Fields, some houses in Pall Mall, and other structures were erected therewith. Mr. Thomas Potter, in his book on "Concrete," written in 1901, says: "In the course of recent alterations at the College of Surgeons it was found that the walls were perfectly sound and apparently in nowise the worse for wear." *Figs.* 3 and 4 are a plan and sections of Ranger's patent mould for making blocks—*g h* are the sides, and *i i* the ends, the sides having two upright grooves, as shown at *h h, h h,* to keep the ends in position, the sides and ends being held together by means of four iron clamps, *j j,* two at each end. Between the ends of each clamp and the sides of the moulds small wedges were driven to keep these clamps tight; *e e* is the bottom of the mould, which is strengthened by ledges, *f f* (*Fig.* 4). *c d* and *l l* show a centre bar which was withdrawn when the concrete had been deposited in the mould; the object of this bar was to allow an iron rod to be inserted for the purpose of rendering the handling or hoisting of the blocks convenient.

The concrete that Mr. Ranger used was composed of powdered grey stone lime, Dorking or Reigate for preference, mixed with various aggregates, principally sea gravel, broken flints, mason's chippings, and similar materials. Hot or boiling water was used for mixing the ingredients. The inventor states in his specification that, from experience, he had found the best results obtained from using 30 lbs. of an aggregate of silicious or other hard kind, 3 lbs. of powdered lime, and 1 lb. 12 oz. of boiling water. He mixed no more of the materials at a time than was sufficient to fill one mould, as the boiling water caused the concrete to set very rapidly. He could remove the sides and ends of the moulds and leave the block resting on the bottom only within ten minutes, and the block so made was fit for use in a fortnight. The material was rammed in the middle to drive out air bubbles, and the top levelled off with a straight-edge. Ranger took out a second patent two years later, in 1834, in which he states that heating the moulds, as well as the use of hot water, expedites the crystallising the the lime, and he also advocates the compression of the concrete in the moulds, the patent describing how these can be constructed to give the compression.

It will be seen from this that Mr. Ranger had perfected at this early date a very good type of mould and method of working, which was not improved upon for many years. The wooden mould, occasionally faced with zinc or sheet iron to improve its wearing qualities, was used up to quite a recent date for the moulding of concrete blocks, and the differences from Mr. Ranger's model were in principle very small.

It was Mr. Spencer Hayward, a builder, of Peckham Rye, who, about 1877, first used and patented iron moulds for making concrete blocks, but these were the size of ordinary bricks; each mould made twenty to fifty bricks, as desired, and consisted of two sides, held together by iron bars and pins, with grooves in which iron divisions were made to slide.

Mr. Joseph Gibbs took out a patent in 1850 for building solid concrete walls by means of timber forms on either side, but in his specification he suggests that, when it was thought advisable to dispense with the forms, the wall might be built of concrete blocks of the size of the stone of which the wall would be composed under ordinary circumstances; but these blocks to be cast hollow instead of solid, "having only sides and ends, the sides and ends being only about 2 in. thick." Mr. Gibbs, however, did not recognise the advantage of the cavities, for he went on to state that in every course of these blocks so built the hollows were to be filled with concrete. He stated that there was no need to put concrete between the blocks to bed them, and he suggests "that instead of the blocks being cast in the shape of hollow parallelograms, they might have merely a back and a face, such back and face being held together by only as much cement or other material as will keep such back and face in parallelism with each other during the time they are setting."



Figs. 3 and 4.
Drawings from Ranger's 1832 Patent Specification.

Up to this date lime concrete seems to have been generally used, although Parker's and other cements were used to a smaller extent. But Mr. Wm. Pidding, who took out a patent in 1851, not only contemplated the use of a different kind of matrix, but also proposed its use for blocks, his invention being for the making of bricks or blocks with 20 per cent. of sulphate of alumina and 70 per cent. of sulphate of lime, and a certain quantity of silica.

The next invention in regard to concrete blocks, so far as we can learn, dates from 1856, when Mr. J. Taylor took out two patents for flanged or ribbed slabs made of concrete, which served as a facing to brickwork and concrete filling, as shown in *Fig* 5, in which A, C, E, F represents the brickwork, A and E being header courses and C and F stretcher courses, and B and D the concrete facing slabs.

Mr. L. D. Owen, in a communication to the Patent Office in 1856, says that building blocks may be formed by mixing one part of slack lime with six to twelve parts of sand or pulverised furnace scoria, brick, or the like, and with the minimum amount of moisture; the lime may be slacked after mixing with the sand. The mixture is then submitted to a pressure of 3 tons per sq. in. in a mould, and is finally dried by exposure to the air. Large blocks are made with holes to facilitate drying.

This would appear to date the formation of hollow blocks from 1856, but apparently the utility of the hollow spaces, in respect to saving weight, securing equability of temperature and dryness, was not recognised, the sole reason for forming these spaces being given as enabling the block to dry more readily.

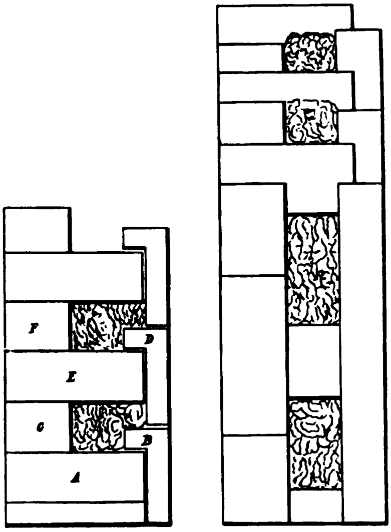
A Mr. J. H. Headley also took out a patent in 1856 for moulding blocks of lime concrete, in which he suggests the advisability of compressing the concrete in the moulds and of silicating the blocks by steeping them in a bath of silicate of soda.

Mr. Matthew Allen, a London builder, took out a patent in 1862 for fire-resisting construction, in which he proposed moulding slabs and other parts of buildings of coke breeze, clinker, or slag concrete, strengthened where necessary with iron bars or rods (*i.e.*, reinforced concrete; Mr. Allen was one of the pioneers in this form of construction).

Mr. J. Taylor, before mentioned, took out a patent in 1862 for improvements on his earlier patent, and a Mr. J. J. Bodmer, in 1865, patented slabs and blocks, either solid or hollow, for forming walls, partitions, floors, etc.

A Mr. F. Ransome, who also was a patentee in connection with reinforced concrete, took out a provisional patent in 1866 for making large hollow bricks or shells of artificial stone, which could be filled with concrete or brickwork, or the spaces left open for heating or ventilation purposes.

Up to this time we see that the sole improvements upon the solid concrete block that had been introduced were to make a hollow space, the advantages of which were not well understood, and to use blocks for facing with a filling of bricks or concrete. This latter idea was not at all novel, as, of course, it only conforms to the method, known to the Romans, of using a facing of tiles with a filling of concrete. The first novel conception seems to have been to use these facing slabs for forming a hollow wall and tying the two skins together by bonders. For this idea, so far as the Patent Records help us, a Mr. S. Harwood is responsible. But he only took out a provisional patent in 1867, and presumably his ideas were not available to the general public, though no doubt he made known his ideas to a few persons, and they gradually had an effect. This provisional patent informs us that Mr. Harwood intended to construct hollow or cellular walls, by laying cement or concrete blocks or slabs "in courses side by side with a space or interval between the rows, which may be two, three, or other in number, and by binding the courses with similar blocks or slabs, either touching each other or with a space between each." He suggested that by leaving openings in the finished walls of the rooms, the ventilation of the entire house could be effected.



SECTION. PLACE.

FIG. 5. TAYLOR'S FACING BLOCKS.

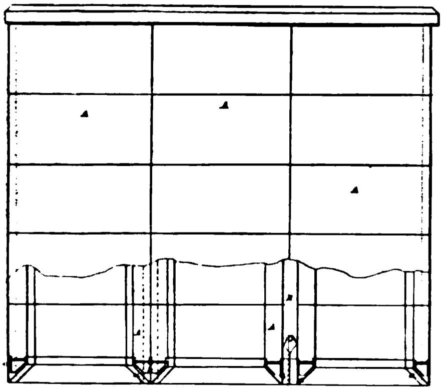


FIG. 6. PART ELEVATION, PART SECTION

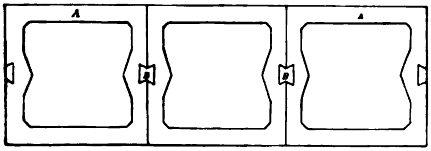


FIG. 7. SECTIONAL PLAN.

FIGS. 6 and 7. BRIDGE PIER CONSTRUCTED OF BUTLER'S HOLLOW RECTANGULAR BLOCKS.

In 1870 a Mr. J. W. Butler, a civil engineer, of Willesden, took out a patent for constructing hollow concrete blocks for caisson foundations. This embodied a slightly different conception of the uses to which concrete blocks could be put, and we reproduce *Figs.* 6 and 7 from his specification, together with the following particulars :—

> My said Invention relates to sea walls, piers, groins, bridges, and other like structures, and to foundations for the same, also to cofferdams, and may be employed in well sinking.
>
> It consists in the application and use to and in such or other like structures or purposes of moulded artificial stone or concrete in the form of hollow blocks of cylindrical or other configuration, or of segments thereof, such hollow blocks, cylinders, or segments being made to answer the purpose of the more costly iron cylinders, brickwork, or other material at

present employed, the cost of the moulded concrete or artificial stone being less than one-half of the cost of the materials heretofore employed for the above purposes. The moulding may be effected in wooden or metal moulds, the core being made in segments temporarily held together whilst the concrete is being moulded, and the said core is withdrawn from the mould in separate parts or segments. When a number of moulded concrete cylinders are required to be placed one on another, as for example in cofferdams, it is proposed to secure them at their points of junction by means of fish pieces bolted or otherwise held in position. A hollow metal shoe made in segments is to be fitted to the bottom cylinder to facilitate the sinking of the same into the ground.

Fig. 6 shows part elevation, part section, and *Fig.* 7 a sectional plan, of a bridge pier. A A are the hollow concrete blocks; B is a dowel guide pile, sunk at the same time as the blocks; *a a* are metal shoes to facilitate the penetration of the blocks into the ground. Circular hollow blocks were also proposed and illustrated by Mr. Butler.

In 1873 a Mr. C. O. Arntz, of Remscheid, Prussia, took out a patent in England for making grooved and tongued blocks which interlocked with each other so as to give rigidity and increased stability. He proposed using these blocks without mortar. *Fig.* 8 shows the form of construction proposed; *a* is an elevation of a block and *b* its plan. At the top of the figure is the elevation of part of a wall built with such blocks, and *f* is a plan showing the top course of blocks.

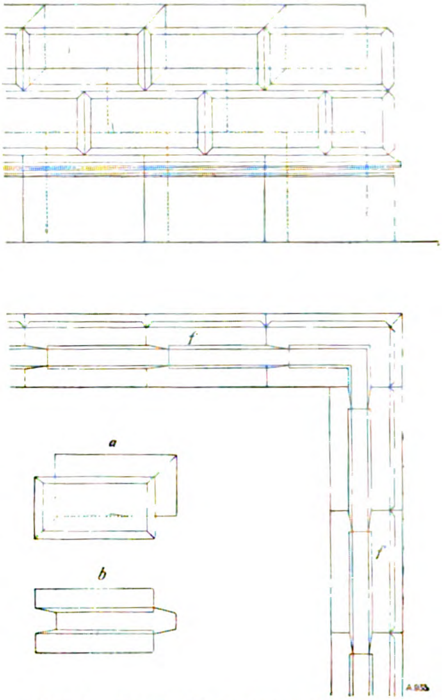
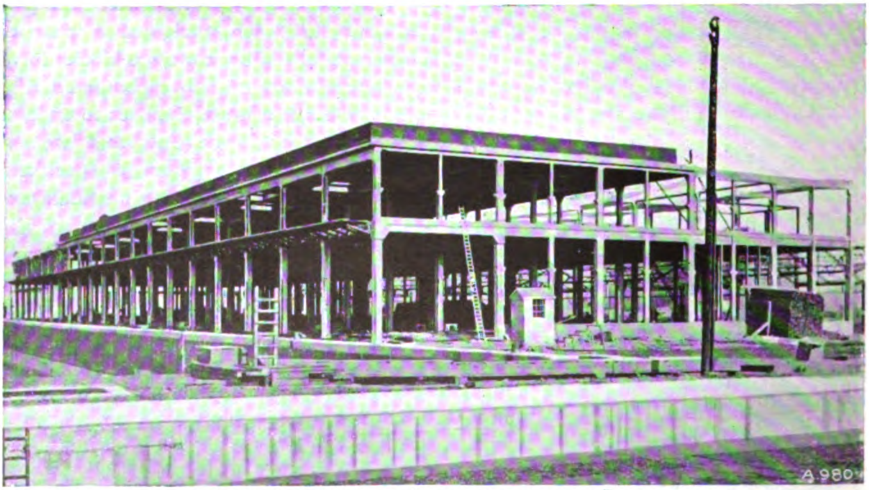


FIG. 8. ARNTZ S GROOVED AND TONGUED BLOCKS.

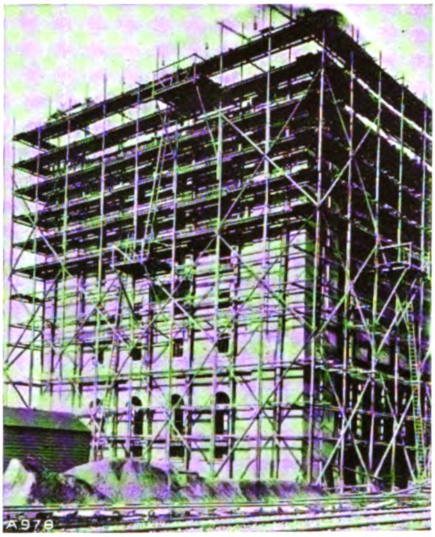
(*To be continued.*)



REINFORCED CONCRETE SHEDS AT AVONMOUTH DOCKS.
Shed No. 1, from the South-West.

REINFORCED CONCRETE SHEDS AND GRANARY AT AVONMOUTH DOCKS.

It affords us pleasure to again be able to present particulars of a work of considerable importance in reinforced concrete—namely, the Transit Sheds and Granary in connection with the Avonmouth Dock improvements.—ED.



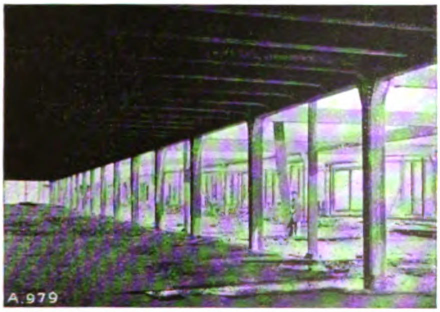
SOUTH ELEVATION OF GRANARY.

IN connection with the new docks at Avonmouth, now in course of construction at a cost of two and a half millions, some important structures in reinforced concrete on the Hennebique System, have recently been completed.

These are two Transit Sheds of two storeys, each 500 ft. long by 96 ft. wide, and a Granary 220 ft. long by 72 ft. wide by about 90 ft. high above ground level, the last-mentioned building being connected with the dock by a reinforced concrete tunnel, for the transport of grain by conveyor belts.

The buildings were designed by Mr. W. W. Squire, M.Inst.C.E., for the Docks Committee of the Bristol Corporation, and drawings for the reinforced concrete work were prepared by Messrs. L. G. Mouchel & Partners, Ltd., of Westminster, to whose Director, Mr. de Vesian, we are indebted for the illustrations here inserted.

The Contractors were Messrs. John Aird & Co., Ltd.

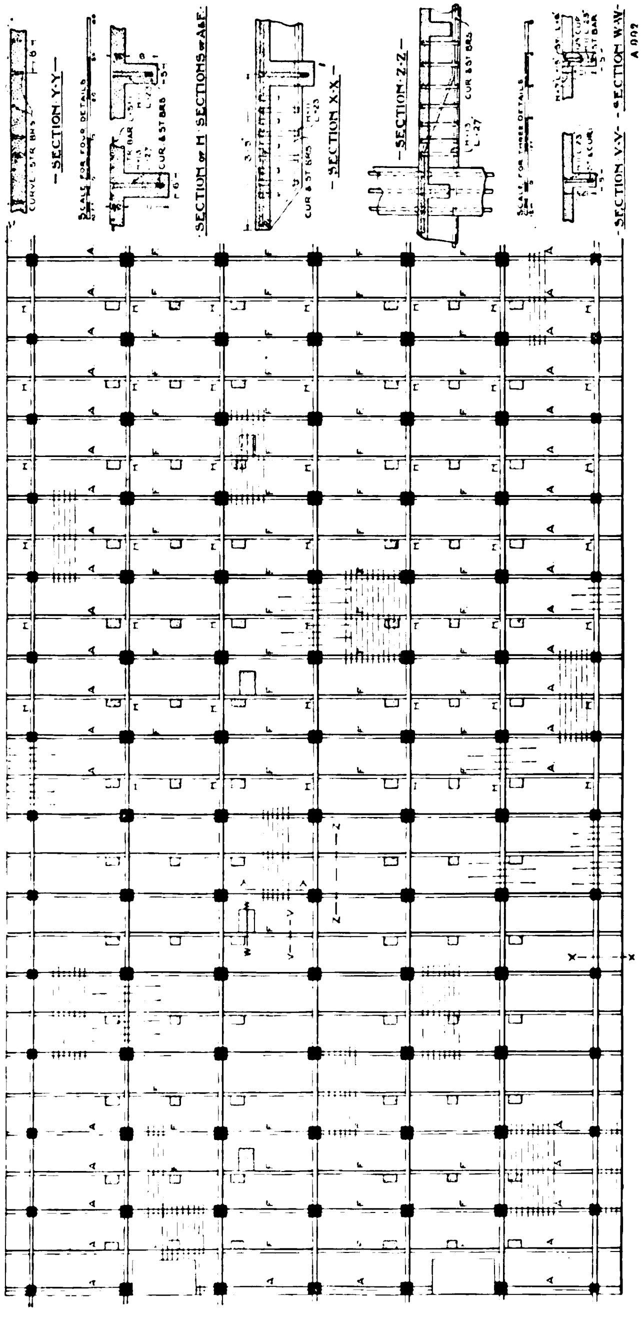


PORTION OF 1ST FLOOR, SHED NO. 1.

The buildings represent the framed system of construction, all loads being transmitted by main and secondary beams to wall and interior columns, and thence direct to the ground. Thus the outer walls carry no load and are merely intended as a protection against the weather.

The drawings show the plans and principal details of the Transit Sheds and Granary, and the photographs give an excellent idea of the extent of the work, which is of considerable interest.

It is not our intention to enter into a detailed description of the design, or building



Reinforced Concrete Granary at Avonmouth Docks. (General plan and details of "Sacking-off" Platform under bins.) *Scale, approximately ⅛ in. = 12 ft.*

operations, as the system adopted and the principles of construction generally applied are well known, but we think that some of the tests undertaken are of considerable value and useful for reference purposes, and we thus give them in greater detail than we do as a rule.

THE TESTS.

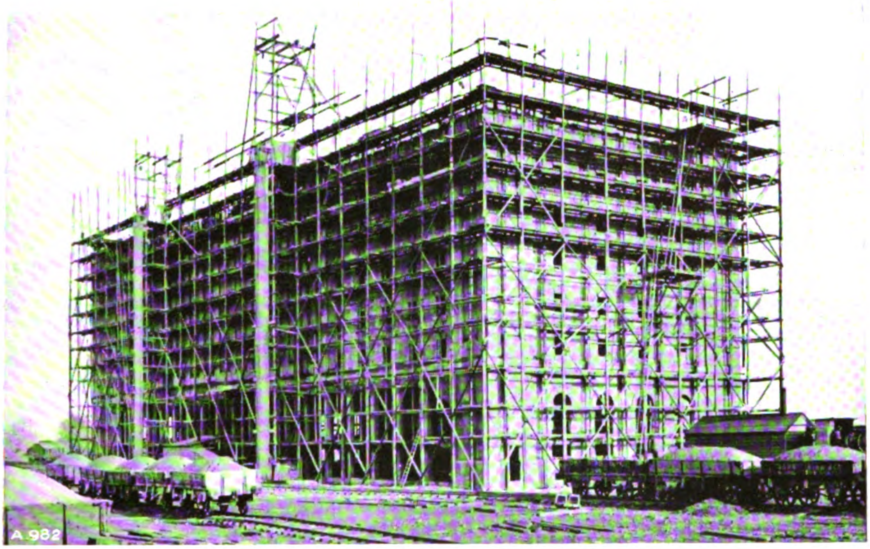
Four series of official tests have been made on the floors and flat roofs of the two Transit Sheds, and as these trials were conducted with exceptional care, we are sure the results will be found of value to our readers. It should be stated that all the concrete was mixed in the following proportions: Portland cement, 6 cwt.; clean sharp sand, 13½ cub. ft.; washed gravel, 27 cub. ft.; making about 31 cub. ft. of concrete.

Tests on Granary Floors.

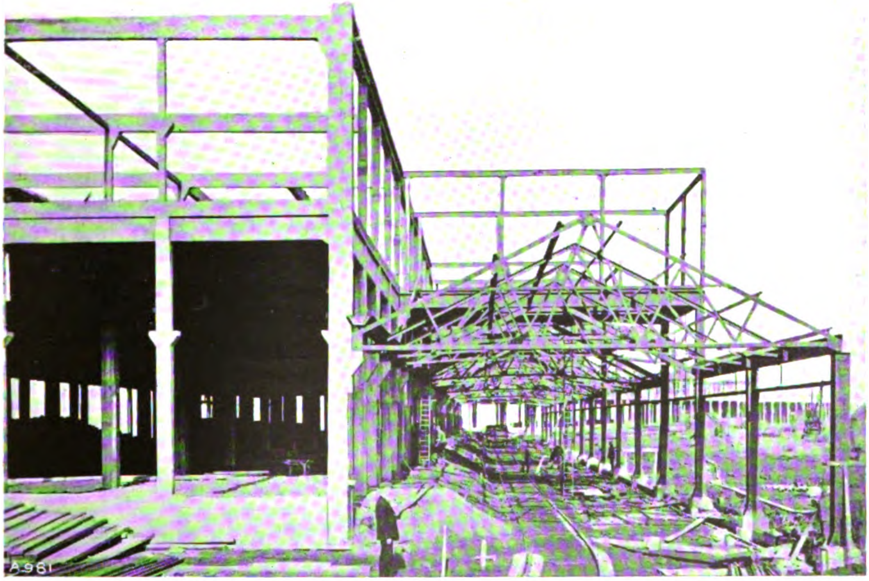
Test No. 1 was conducted upon a portion of the sacking platform, the area loaded measuring 23 ft. 6 in. by 20 ft., and supported by one of the main floor beams, with the width of 7 in., the depth of 13 in., the span of 20 ft., and finished by the continuous floor slab 3½ in. thick.

Three sensitive deflectometers were placed beneath the beam, one at the middle and one at each end of the span, so that accurate readings could be obtained of the maximum deflection.

Loading was commenced at 10.15 a.m. on April



Granary from the South-West.



Shed No 1. Loading Way.

REINFORCED CONCRETE STRUCTURES AT THE AVONMOUTH DOCKS.

24th, and at 11.40 a.m. the maximum deflection under the normal working load of 35 tons 5 cwt. was 0·99 in., or nearly $\frac{3}{32}$ in.

At 1.50 p.m. on the same day, the maximum deformation under the full test load of 52 tons 17 cwt. was 0·118 in., or less than $\frac{1}{8}$ in., representing the proportion of $\frac{1}{2400}$ the span of the main beam as compared with $\frac{1}{600}$ the span allowed by specification.

In order to test the elastic properties of the construction, readings of deflection were taken during the removal of the load, the result being that as soon as the floor area had been unloaded the deflection was reduced to 0·0315 in., or about $\frac{1}{32}$ in., thus testifying in a completely satisfactory manner the elasticity of the reinforced concrete work.

Test No. 2 was conducted on another portion of the sacking platform measuring 23 ft. 6 in. by 10 ft., and supported by one of the main beams 6 in. wide by 11 in. deep with the span of 10 ft., and finished by the 3½ in. thick floor slab.

As in Test No. 1, three deflectometers were placed beneath the beam, and the operation of loading was started at 2 p.m. on April 24th. At 3.15 p.m., under the normal load of 17 tons 12 cwt. the maximum deflection of the beam was barely 0·079 in., or only $\frac{5}{64}$ in. At 3.52 p.m., under the full test load of 26 tons 6 cwt. no further increase of deflection was registered. Therefore the total deflection was not more than $\frac{1}{1500}$ the span as against $\frac{1}{600}$ permitted by specification. Immediately on removal of the loading the deflection was reduced to 0.039 in., which being little more than $\frac{1}{32}$ in. must be regarded as a satisfactory proof of the elasticity possessed by the construction. In order to render these records of practical value to our readers, we give details of the floor construction, and add the information that the

TABLE I. TESTS OF FIRST FLOOR BAY, NO. 6, IN TRANSIT SHED NO. 1 (AVONMOUTH DOCKS).

	Date	Hour	Load on Main Beam in Tons	Deflection in decimals of an inch at Deflectometers, situated as stated			Remarks
				No. 1 End of Beam	No. 2 Middle of Beam	No. 3 End of Beam	
Loading started ...	1908 Mar. 12	10.45 a.m.	—	—	—	—	Age of concrete, 25 weeks.
Normal load on ...	,,	3.50 p.m.	90	·0315	·185	·0315	Maximum Deflection ·346−·0472=·298 in., or less than three-fifths the permissible deflection.
Loadingre-started ...	Mar. 13	9.10 a.m.	90*	·0236	·188	·0275	
Test load on	,,	12.24 p.m.	135	·0 72	·340	·0472	
,, ,,	,,	1 35 p.m.	135	·0472	·346	·0472	
Unloading started ...	Mar. 13	1.35 p.m.	135	·0472	·346	·0472	
Normal load on ..	,,	4.17 p m.	90	·0355	·310	·0355	Permanent Deformation ·078−·0158=·055 in.
Load off ...	Mar. 14	10. 0 a.m.	—	·0158	·071	0158	

* *NOTE.—The normal load of 90 tons was left on the floor for seventeen consecutive hours.*

TABLE II. TESTS OF FIRST FLOOR BAY, NO. 10, IN TRANSIT SHED NO. 1 (AVONMOUTH DOCKS).

	Date	Hour	Load on Main Beam in tons	Deflection in decimals of an inch at Deflectometers situated as stated below.			Remarks
				No. 1 End of Beam	No. 2 Middle of Beam	No. 3 End of Beam	
Loading started ...	1908 Mar. 13	2. 0 p.m.	—	—	—	—	Age of concrete, 21 weeks.
Normal load on ...	,,	5.35 p.m.	90	·0236	·142	·0236	Maximum Deflection ·221 − $\frac{(·0394 + ·0315)}{2}$
Loading re-started ...	Mar. 14	6.35 a.m.	90*	·0236	·146	·0236	
Test load on	,,	9.15 a.m.	135	·0394	·221	·0315	= ·185 in., or less than two-fifths the permanent deflection.
Unloading started ...	Mar. 14	9.45 a.m	135	·0394	·221	·0315	Permanent Deformation ·0315 − $\frac{(·0039 + 0)}{2}$
Normal load on ...	,,	10.53 a.m.	90	·0315	·165	·0236	
Load off ...	,,	12.45 p.m.	—	·0039	·0315	—	= ·0295 in.

* *NOTE.—The normal load of 90 tons was left on the floor for eleven consecutive hours.*

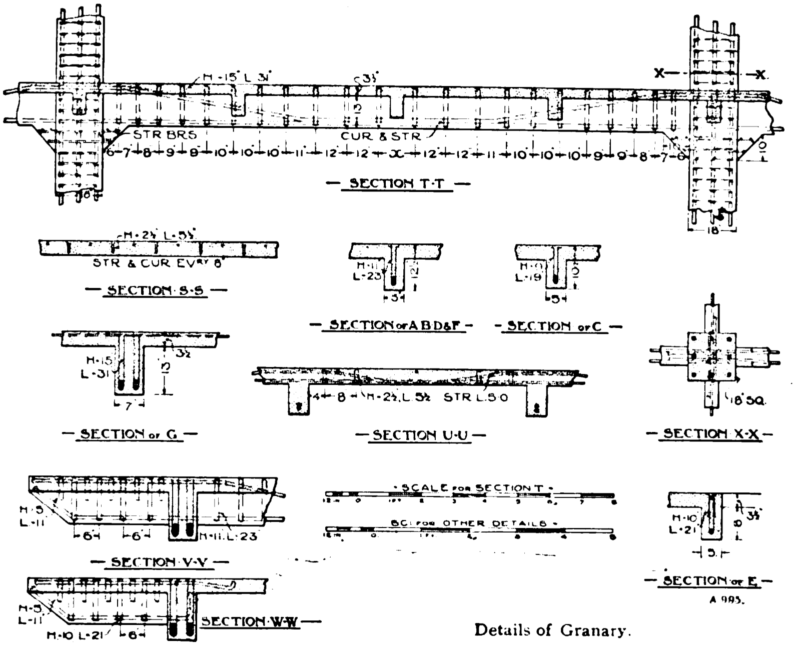
Series I. First Floor of Transit Shed No. 1.—The areas selected for the tests were Bays No. 6 and No. 10, with the superficial dimensions of 25 ft. by 24 ft., equals 600 sq. ft.

Each of the floor areas is carried by a main beam measuring 12 in. wide by 29 in. deep, including 5 in. the thickness of the floor slab.

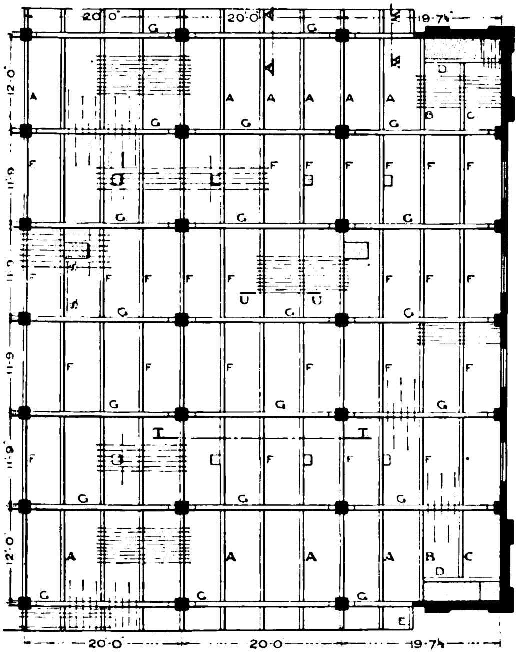
The floor was designed for the superload of 3 cwt. per sq. ft., the test superload being 4½ cwt. per sq. ft.

The proportionate deflection of the main beam permitted by the engineer's specification was $\frac{1}{600}$th of the span, or 0·5 in.

The observations made during the tests are summarised in Tables I. and II.



Details of Granary.



Scale approximately ½ in. = *12 ft.*

Reinforced Concrete Granary at Avonmouth Docks.

(Plan of "Sacking-off" Platform. Floor granary.)

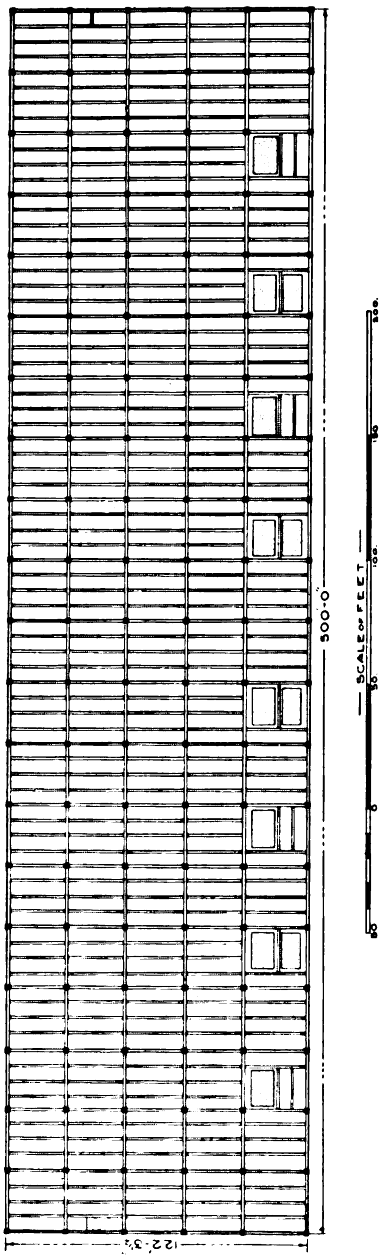
concrete was composed of Portland cement 6 cwt., sand 13½ cub. ft., washed gravel 27 cub. ft., and at the time of the tests was about nine months old.

Comparison of the foregoing tables brings out the apparently anomalous result that the beam in Bay No. 10, although with concrete only 21 weeks old, was stiffer than the beam in Bay No. 6 with concrete at the age of 25 weeks.

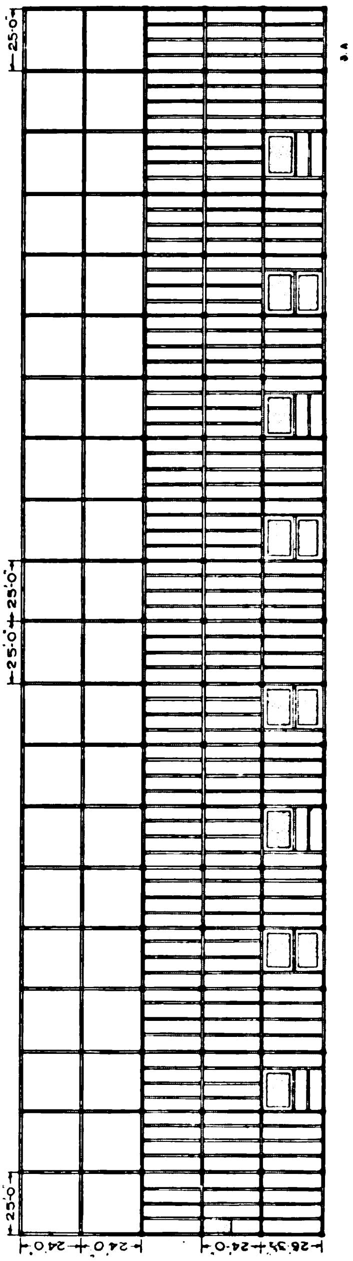
Apart from practical errors of observation, which, of course, are unavoidable in tests of every description, differences of workmanship may possibly account for the slight discrepancy, but the point is worthy of note as emphasising the necessity for ample factors of safety in reinforced concrete design.

In the present case the more pliable of the two beams possessed nearly double the resistance to deflection demanded by the specification, and so more than complies with all reasonable demands.

But in these days of competition, there is a risk that some designers and contractors, who are new to reinforced concrete work, may attempt to cut things too fine in the endeavour to secure business, a practice sufficiently undesirable in the general way, and particularly dangerous in reinforced concrete construction.



Reinforced Concrete Sheds at Avonmouth Docks
(Plan of first floor; view from beneath.)



Plan of roof; view from beneath.

Series II. Roof of Transit Shed No. 1.—The areas selected for these tests were Bays No. 9 and No. 16, with the superficial dimensions of 25 ft. × 24 ft. = 600 sq. ft. In the roof construction the beams and slab are of the same proportion and designed for the same loads as the corresponding members in the first floor of the same building.

The test load and the permissible deflection specified by the Engineer were 135 tons and $\frac{1}{800}$th of the main beam span as before. The results of the tests are summarised in Tables III. and IV.

These two sets of tests give approximately equal results, the deflection being far below the permissible limit in each case and the permanent deformation exceedingly small, thus demonstrating the almost perfect elasticity of the construction.

TABLE III. TEST OF FOOF BAY, NO. 9, IN TRANSIT SHED NO. 1 (AVONMOUTH DOCKS).

	Date	Hour	Load on Main Beam in Tons	Deflection in decimals o an inch at Deflectometers situated as stated below. No. 1 End of Beam	No. 2 Middle of Beam	No. 3 End of Beam	Remarks
Loading started	Mar. 19	9.20 a.m.	—	—	—	—	Age of Concrete, 18 weeks
Normal load on	,,	3.25 p.m.	90	·0078	·134	·0280	Maximum Deflection ·24—·0394 = ·2 in., or less than two-fifths the permissible deformation.
Test load on	,,	5.35 p.m.	135	·0315	·228	·0315	
Test load on	Mar. 20	6. 0 a.m.	135*	·0394	·240	·0394	
Unloading started	,,	6. 0 a.m.	135	·0394	·240	·0394	Permissible Deformation ·051— $\frac{\cdot0078\times0}{2}$ = ·0471 in.
Normal load on	,,	8.47 a.m.	90	·0354	·181	·0236	
Load off	,,	12.25 p.m.	—	·0078	·051	—	

**NOTE.—The test load of 135 tons was left on the roof for thirteen consecutive hours.*

TABLE IV. TEST OF ROOF BAY, NO. 16, IN TRANSIT SHED NO. 1 (AVONMOUTH DOCKS).

	Date	Hour	Load on Main Beam in Tons	Deflection in decimals of an inch at Deflectometers situated as stated below No. 1 End of Beam	No. 2 Middle of Beam	No 3 End of Beam	Remarks
Loading started ...	1908 Mar. 20	6.15 a.m	—	—	—	—	Age of concrete, 17 weeks.
Normal load on ...	,,	10.17 a.m.	90	·0236	·122	·0315	Maximum Deflection $\cdot221 - \frac{\cdot0442 + \cdot0433}{2}$ = ·172 or less than [illegible]th the permanent deflection.
Test load on	,,	12.25 p.m.	135	·0512	·203	·0433	
,, ,,	,,	1.50 p.m.	135	·0552	·221	·0433	
Unloading started ...	,,	1.50 p m.	135	·0552	·221	·0433	Permanent Deformation $\cdot0394 - \frac{\cdot0118+\cdot0078}{2}$ = ·0296 in.
Normal load on ...	,,	5.30 p.m.	90*	·0512	·301	·0315	
Load off ...	Mar. 21	12.10 p.m.	—	·0118	·0394	·0078	

**NOTE.—The normal load of 90 tons was left on the roof for fifteen consecutive hours.*

Series III. First Floor of Transit Shed No. 2.—The areas selected for these tests were Bays No. 10 and No. 3, the superficial dimensions, the construction, the loading, and the test conditions being the same as in the case of Series I. and II.

Tables V. and VI. give particulars of the results obtained.

TABLE V. TEST OF FIRST FLOOR BAY, NO. 10, IN TRANSIT SHED NO. 2 (AVONMOUTH DOCKS).

	Date	Hour	Load on Main Beam in Tons	Deflection in decimals of an inch at Deflectometers situated as stated below No. 1 End of Beam	No. 2 Middle of Beam	No. 3 End of Beam	Remarks
Loading started ...	1908 Mar. 20	2.30 p m.	—	—	—	—	Age of concrete 13 weeks.
Normal load on ...	Mar 21	10.25 a.m.	90	·0236	·122	·0236	Maximum Deflection $\cdot209 - \frac{\cdot0472 + \cdot0512}{2}$ = ·159
Test load on	,,	1.13 p.m.	135	·0472	·209	·0512	
Unloading started ...	,,	1.13 p.m.	135	·0472	·209	·0512	Permanent Deformation: $\cdot035 - \frac{\cdot0039+0}{2}$ = ·0335 in.
Normal load on ...	,,	2.40 p.m.	90	·0354	·149	·0039	
Load off ...	Mar. 23	11.10 a.m.	—	·0039	·035	—	

**NOTE.—The normal load of 90 tons was left on the floor for about forty consecutive hours.*

TABLE VI. TEST OF FIRST FLOOR BAY, NO. 3, IN TRANSIT SHED NO. 1 (AVONMOUTH DOCKS).

	Date	Hour	Load on Main Beam in Tons	Deflection in decimals of an inch at Deflectometers situated as stated below			Remarks
				No. 1 End of Beam	No. 2 Middle of Beam	No. 3 End of Beam	
Loading started ...	1908 Mar. 23	6. 0 a.m.	—	—	—	—	Age of concrete, 15 weeks.
Normal load on ...	,,	9.10 a.m	90	·0315	·138	·0394	Maximum Deflection $\cdot252-\frac{\cdot0552+\cdot0630}{2}$
Test load on	,,	11.13 a.m.	135	·0552	·252	·0630	$=\cdot193$ in.
Unloading started ...	,,	11.13 a.m.	135	·0552	·252	·0630	Permanent Deformation $\cdot055-$
Normal load on ...	,,	1. 0 p.m.	90	·0315	·181	·0394	$\frac{\cdot0039+\cdot0078}{2}$
Load off ...	,,	3.25 p.m.	—	·0039	·055	·0078	$=\cdot049$ in.

TABLE VII. TEST OF ROOF BAY, NO. 9, IN TRANSIT SHED NO. 2 (AVONMOUTH DOCKS).

	Date	Hour	Load on Main Beam in Tons	Deflection in decimals o an inch at Deflectometers situated s stated below.			Remarks
				No. 1 End of Beam	No. 2 Middle of Beam	No. 3 End of Beam	
Loading started ...	1908 Mar. 27	7 30 a m.	—	—	—	—	Age of concret , 3½ weeks.
Normal load on ...	..	11.50 a.m	90	·0275	·181	·0394	Maximum Deflection,
Test load on	..	1.45 p.m.	135	·0472	·319	·0512	$\cdot319-\frac{\cdot0472+\cdot0512}{2}$ $=\cdot27$ in.
Unloading started ...	..	1.45 p.m.	135	·0472	·319	·0512	
Normal load on ...	..	3.50 p.m.	90	·0394	·252	·0394	Permanent Deformation
Load off ...	..	5.30 p.m.	—	·0039	·0472	—	$\cdot0472-\frac{\cdot0039+0}{2}$ $=\cdot0452$ in.

TABLE VIII. TEST OF ROOF BAY, NO. 3, IN TRANSIT SHED NO. 2 (AVONMOUTH DOCKS).

	Date	Hour	Load on Beam in Tons	Deflection in decimals of an inch at Deflectometers situated as stated below			Remarks.
				No. 1 End of Beam	No. 2 Middle of Beam	No. 3 End of Beam	
Loading started ...	1903 Mar. 27	1.50 p.m.	—	—	—	—	Age of concrete, 8 weeks.
Normal load on ...	..	4.30 p m.	90	·0315	·169	·0354	Maximum Deflection,
Test load on	Mar. 28	7.40 p.m.	135	·0552	·309	·0512	$\cdot309-\frac{\cdot0552+\cdot0512}{2}$ $=\cdot256$ in.
Unloading started ...	..	7.40 p.m.	135	·0552	·309	·0512	
Normal load on ...	..	9.10 p.m.	90	·0472	·258	·0433	Permanent Deformation,
Load off ...	..	12.45 p.m.	—	·0078	·051	—	$051-\frac{\cdot0078+0}{2}$ $=\cdot047$ in.

NOTE. This Bay was under a heavy load throughout the night of March 27-28.

These results are so close as regards deflection that, having regard to slight variations in the readings, it is scarcely possible to differentiate between the stiffness and elastic behaviour of the two bays, which show very advantageously in relation to the permissible deflection specified.

Series IV. Roof of Transit Shed No. 2.—The areas tested were Bays No. 9 and No. 3, the measurements, construction, loading, and test conditions being the same as in the other series of tests.

Tables VII. and VIII. summarise the observed results.

Like all the previously mentioned results, the figures in Tables VII. and VIII. are of particularly satisfactory character, demonstrating not only the great rigidity and elastic strength of the construction, but also pointing to the conservative nature of the designs and the excellent character of the work performed by the contractors.

REINFORCED CONCRETE HOLLOW FLOORS CONSTRUCTED WITHOUT CENTERING.

By FREDERIC R. FARROW, F.R.I.B.A.

The question of constructing floors without using any centering is becoming an all-important problem in our building practice, and we thus present from the pen of an architect who is in close touch with the architectural problems of the Metropolis an article dealing with this subject.

There are two methods of dealing with this problem—one by designing in conjunction with steel joists and the other by designing in reinforced concrete proper. Where the steel joists have been employed, concrete is generally used, but there has also been a tendency to utilise terra-cotta, and, what is more, dense terra-cotta, in place of concrete. The latter method is certainly to be deprecated, as there are so many reasons why dense terra-cotta is unsatisfactory.

In one direction, however, these problems of floor construction have not been advanced as they should have been, for, with the exception of the "Armoured Tubular" floor, none of the floors dealt with in the article have as yet passed the official tests for fire resistance in this country, nor have any attempts been made to pass such tests, except in the case of the Visintini Floor, when a floor of 10ft. span failed. The Armoured Tubular Flooring Co. thus alone holds the British official fire record among the floors not requiring centering.

Architects and engineers have many uses for floors where the fire problem cannot arise, but where the fire problem does arise, it would be well for them to limit their specifications to floors that have passed official tests, as there are in our days so many floors to choose from that have passed these tests, that it is unwise for them to run any risks experimenting with untested work, even where the advantage of no centering is offered.—ED.

THERE can be no doubt that reinforced concrete hollow floors will in the near future hold a very prominent position.

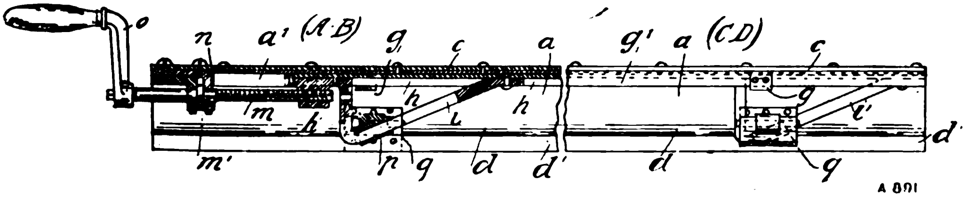
Two obvious advantages that they possess are lightness and reduced permeability to sound as compared with solid floors, whilst in respect of fire-resisting and weight-carrying capabilities, the experiments so far completed are by no means unsatisfactory.

We therefore feel that a full account both of the construction and of the manufacture of a typical floor of this type will interest our readers, and as the example we have selected the Siegwart floor, which may be regarded as a pioneer of this class of floor.

The Siegwart Floor.—This floor consists of a series of hollow beams laid side by side from girder to girder, or in the case of limited spans from wall to wall.

In the construction of a floor with Siegwart hollow beams, these are made in a factory to the exact length required, transported to the building, and laid in position side by side. Practically, the beams do not quite touch, and the joints between them are pointed on the underside with plaster of Paris and then grouted from above with cement. The lower surfaces can then be finished in any way desired, being sufficiently fair to require only lime-whiting or distempering in factories, and capable of receiving a setting coat of plaster if a fairer face is deemed advisable. Similarly, the upper face can be covered with wood floor, mosaic, or other material, and can be adapted for

Fig. 1.



flat roofs, to be covered with Congo Roofing, Ruberoid, Vulcanite, or similar materials.

It will be evident that amongst the advantages of this method are the needlessness of centering, lightness, facility of erection (so that floors may be laid directly the walls are ready, and thus save much internal scaffolding), possibility of close supervision in the works during manufacture, good insulation from heat and sound—the hollow beams having much less conductivity than a solid concrete floor—speedy drying of the floors as compared with concrete laid *in situ*.

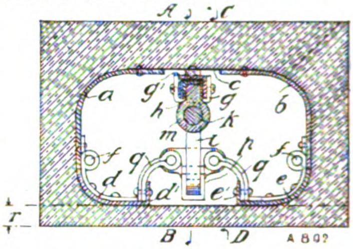


Fig. 2.

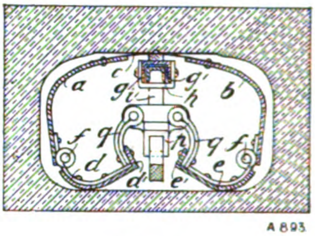


Fig. 3.

The spans to which the Siegwart beams are applicable without intermediate supports may be anything up to 19 or 20 ft.

For intermediate supports ordinary rolled steel joists, with the bottom flange and lower part of the web encased in concrete which forms a bearing for the Siegwart beams, are used, or in some cases reinforced concrete beams.

In some buildings that have been erected may be seen an application of the Siegwart beam, which reproduces the undoubtedly scientific and hygienic merits of the ancient Roman hypocaust floor. The ends of the beams are connected by chases formed in the walls, as shown in the plan, *Fig.* 4, so that heated air from a central station passes by vertical flues to the floor and circulates through its entirety. Rooms are thus warmed by an evenly-distributed radiation from their floors and ceilings, and the result is not only agreeable and healthy, but is also said to be economical. The hollow beams are also in some cases utilised for ventilation, as illustrated in *Fig.* 5.

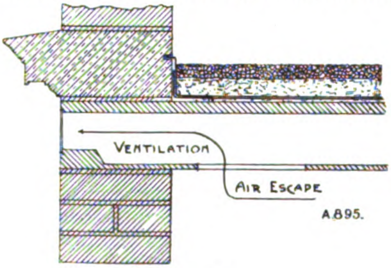


Fig. 5.

For varying spans and loads the beams are made of varying depth and varying thickness of the concrete at top and bottom, the breadth of the beams being always 10 in. and the thickness of side walls 1 in. (2.5 cm.) to 1⅛ in. The diameter of the iron tension rods and their number also vary, and the subjoined table gives the number and diameter in the standard sizes with the safe loads for which they are designed.

If still stronger beams are required they can be made of greater depth, and rods are used up to $\frac{7}{16}$ in. diameter.

Section of beam		Iron rods		Wght. of beam per lin. ft	Safe distributed loads in cwts. per square foot (dead weight of beams included).										
Depth	Width	No.	Diam.		Cwts.	¼	½	¾	1	1¼	1½	1¾	2	2¼	2½
ins.	ins.		ins.	lbs.	Spans										
4¾	10	4	$\frac{5}{32}$	24	..	12′	10′	8′ 3″	7′ 4″	6′ 7″					
4¾	10	2 2	$\frac{5}{32}$ $\frac{7}{32}$	24	..	14′ 5″	11′ 5″	10′	9′	8′					
6	10	2 2	$\frac{3}{16}$ $\frac{7}{32}$	27	..	16′ 9″	13′ 5″	12′	11′	10′	9′	8′ 6″			
6	10	6	$\frac{3}{16}$	27	..	18′	15′	13′ 4″	12′	10′ 10″	10′ 2′	9′ 2″			
7	10	6	$\frac{3}{16}$	30	..	...	16′ 5″	14′ 8″	13′ 2″	12′	11′ 3″	10′ 7″	10′	9′ 6′	
7	10	6	$\frac{7}{32}$	30	..	...	19′ 1″	17′	15′ 1″	14′	13′	12′ 2″	11′ 6″	11′	
8¼	10	6	$\frac{7}{32}$	33	..	...	20′ 4′	18′ 5″	16′ 4″	15′ 3″	14′	13′ 4″	12′ 6″	12′	11′ 6″
8¼	10	6	¼	33	..	...	22′ 5″	20′	18″	16′ 7″	15′ 5″	14′ 10″	13′ 9″	13′	12′ 3″
9⅜	10	8	¼	43	..	...	...	...	...	20′ 3″	18′ 9″	18′	17′	16′	15′ 5″
9⅜	10	6 2	[illegible] $\frac{7}{32}$	54	..	...	...	...	...	20′ 10″	19′ 7″	18′ 5″	17′ 7″	16′ 9″	16′

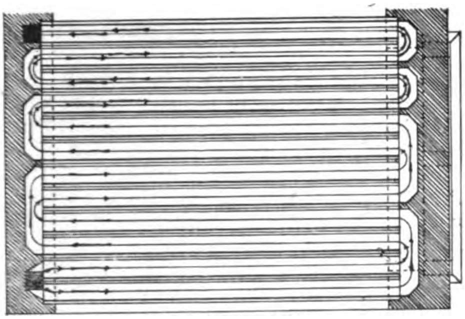


Fig. 4.

In a normal section with six rods, two run parallel to the lower edge of the beam and the other two are parallel thereto only for the middle portion of their length (about one-third) and then rise upwards near the supports, with the view of meeting the increased shearing stress. All are bent round at the ends into loops, which increase the hold of the iron on the concrete and further assist to take up the shearing stresses.

The hollow in the beams is formed by means of ingenious expanding metal cores or moulds, which are illustrated in *Figs.* 1, 2 and 3.

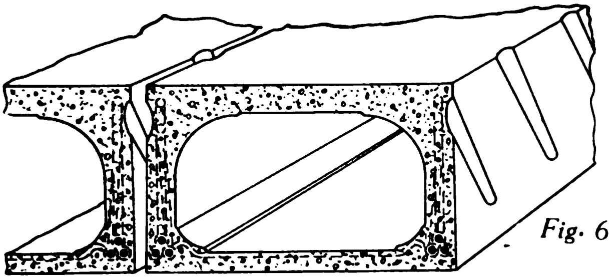


Fig. 6

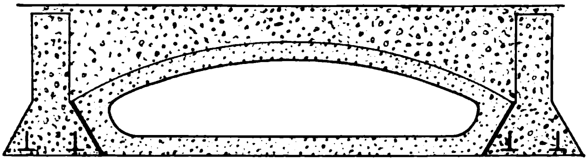


Fig. 7.

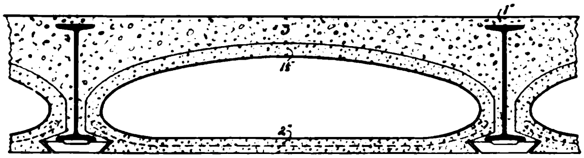


Fig. 8.

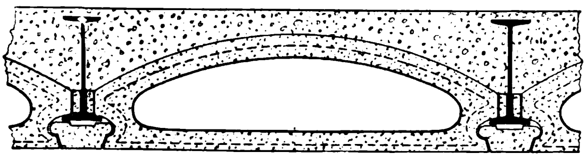


Fig. 10.

Fig. 1 shows the core in longitudinal section on lines A-B and C-D of *Fig.* 2.

Figs. 2 and 3 are cross-sections of the core and of a moulded beam cast round it.

The outer surface of the core is constituted by upper longitudinal parts *a*, *b*, made of curved metal plates pivotally connected together at their adjacent edges by a thin steel plate *c*, and by under longtudinal parts *d*, *e*, also made of metal plate and connected to the lower edges of the upper longitudinal parts *a*, *b* by means of hinges *f*, and provided with inwardly bent lower edges or flanges *d'*, *e'*. Under the steel connecting plate *c* is arranged in a guide rail *g'*, supported by brackets *g*, a bar *h*, to which are secured sliding brackets *i* and *i'*, provided with inclined sliding surfaces. The end of the bar *h* is provided with a nut *k*, with which engages a screw spindle *m*, supported in a guide or angle-irons *n* and secured against longitudinal movement by a collar *m'*. To the spindle *m* is secured a crank *o*. Sliding blocks *p* are movably mounted on the inclined sliding surfaces of the brackets *i* and *i'* and are hinged to the longitudinal parts *d* and *e* by means of hinged arms *q*. In casting a beam the core, in its expanded position and with the tensional iron rods attached by means of wires passing round the core, is placed on a layer of concrete *r* (*Fig.* 2), which on completion forms the bottom of the beam.

Ten of these cores are arranged in a tier at suitable distances to furnish the required thickness of the side walls, and the concrete having been compounded in a mixing machine is fed between and over the cores by hand in most of the factories. The tier is then, whilst the concrete is still moist, divided into ten separate girders by a machine actuating a plunging blade, which simultaneously moves downwards and laterally. This machine, like the expanding cores, is patented (British Patent No. 984. A.D., 1903). On the sides of the plunging blades are a series of rounded and tapered projections which form a corresponding series of indentations on the sides of the beams. These indentations serve to form a key for the grouting between the beams when the floor is laid, and thus connect the beams and form joggled joints between them.

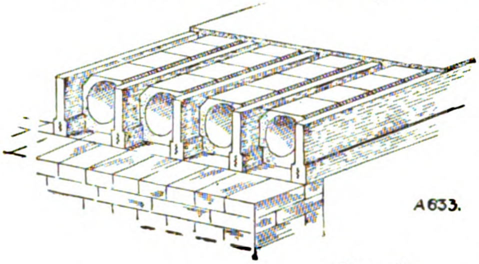


Fig. 9.

When the concrete is set, to remove the core the spindle *m* (*Figs.* 1, 2 and 3) is rotated by means of the crank *o*, so that the nut *k*, together with the bar *h* and inclined brackets *i* and *i'*, are drawn towards the crank. Owing to this movement and to the inclination of the sliding surfaces of the brackets *i* and *i'*, the slide-blocks move on these surfaces vertically upwards, whereupon the arms *q* hinged to them cause the lower longitudinal parts *d, e,* as well as the upper parts *a, b,* to move or collapse inwardly about their hinges, the steel plate piece *c* being at the same time bent, as it acts as a hinge connection for the upper longitudinal members (*Fig.* 3). The circumference of the core is thus reduced so that it can be easily withdrawn from the hollow girder.

In *Fig.* 6 is shown a section and oblique projection of a completed beam.

In the newest factories for the manufacture of Siegwart beams an improved machine (British Patent No. 9955. A.D., 1905), driven by electric motor, is used, which mixes the concrete, forms the tier of beams, and separates it into separate beams.

The concrete is composed of 1 part of Portland cement to 4 parts of river sand screened through a sieve of $\frac{3}{8}$-in. mesh, it, therefore, contains a fair proportion of large-sized particles, some as much as $1\frac{1}{4}$ in. long. The cement has a breaking tensile stress of 35 kg. per sq. cm. on a neat cement briquette three weeks old.

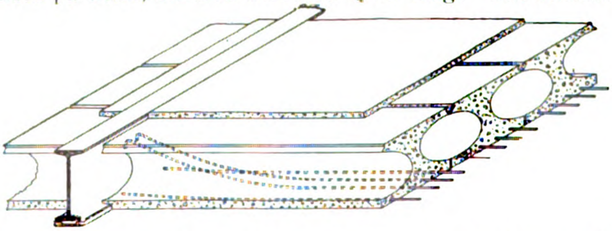


Fig. 11.

Numerous load tests have been conducted with floors of Siegwart Beams, but there is no fire test in this country or abroad that fully coincides with the conditions required for classification as " fully protective " under the International Standards.

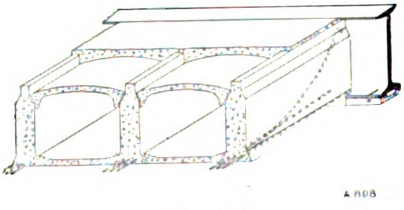


Fig. 12.

The Armoured Tubular Floor.—A typical example of a separate group in the class of reinforced concrete hollow floors constructed without centering is that known as the Armoured Tubular Floor (*Fig.* 9), which was fully described and illustrated in our issue for September, 1907. Vol. II., pp. 336 to 338. In this group the reinforcement is confined to lintels or bearers, on which rest the hollow tubes that make up the bulk of the floor. The advantages possessed by the Siegwart type of floor are certainly to be found in those floors that have the reinforcement restricted to bearing members supporting hollow tubes. The Armoured Tubular floor having been so fully dealt with in this Journal, description at this point would seem unnecessary, but we would point out that the floor has passed an eminently satisfactory fire test at the British Fire Prevention Committee's testing station, obtaining the highest classification obtainable as a fire resistant, and the floor can be safely specified for fire protective purposes. The test was the four hour test at temperatures over 1800° Fahr.; followed by the application of water. The floor was also tested as to load carrying capacity by the Committee and the result was reported in our issue of September, 1907. Vol. II., p. 337.

The National Fireproofing Co.'s Floors.—This firm construct and supply floors of both the types to which we have referred. In *Fig.* 7 is seen a section of that with lintels of concrete reinforced by small steel T-irons, and formed with skewbacks for the support of hollow beams filled in above with concrete to produce a level floor. In *Fig.* 8 we show a section of the floor used by this Company, with deep joists placed not more than 4 ft. 6 in. apart, centre to centre, in which the hollow beams are reinforced by steel rods, the thickness of the concrete in these beams being 2 in. at bottom and 1½ in. at top, and the reinforcement being placed in the bottom of the beam as shown. The protection for the bottom flanges of the deep steel joists is provided by wedged-shape terra-cotta soffite tiles. This variety of floor has been constructed by the Company in the New Royal Infirmary, Manchester.

As to fire resistance, the National Fireproofing Co. have had a floor officially tested by the British Fire Prevention Committee, but not one of the type under review, and thus nothing authoritative can be said as to the fire qualities in this case.

This Company also make a floor with a slight variation, as the section shown in *Fig.* 7, the lintels being formed with a rebated section and reinforced with rods, thus producing a very similar floor to that of the Armoured Tubular Flooring Co., Ltd. In the construction of floors with reinforced lintels supporting tubes it seems the general practice to make the tubes in short lengths for facility of handling. The lintels must necessarily be in one length between the supports.

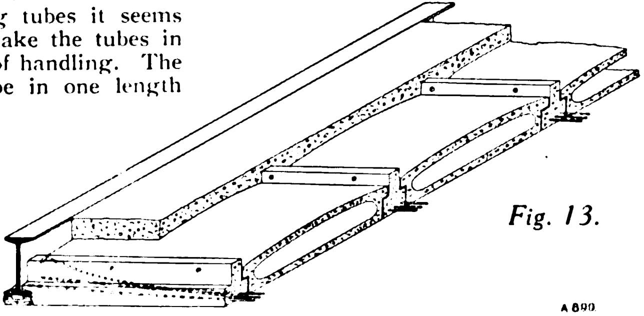


Fig. 13.

The Somerville Floor (Messrs. D. G. Somerville & Co.).—One of these floors, shown in section in *Fig.* 10, consists of hollow reinforced concrete tiles, which are moulded or cast at the works. Each tile is reinforced with $\frac{3}{16}$-in. steel rods wound spirally throughout top and bottom rims. The soffit of the tile projects below the bottom flanges of the joists, giving a level ceiling ready for finishing coats of plaster. The bottom flanges are further protected by a small concrete filling piece, which provides for an air channel, which, in the event of fire, tends to keep the steel immune from damage. The haunches of the tiles, which rest on the bottom flanges of rolled steel joists of suitable section, are grouted in with a cement and sand fillet, which gives a solid bearing and fills up all interstices. The top is then filled in with good clinker concrete, which is finished ready to receive floor battens or granolithic. The finished floor weighs only 35 lb. per sq. ft.

The large air-spaces formed by the construction ventilate the floor and deaden all sound passing through, forming a sound-proof floor, which in public buildings or flats is a most important factor.

The tiles are all tested to carry a live load of 3 cwt. per sq. ft., and have been loaded up to 18 cwt. per sq. ft. without failure.

The United Kingdom Floors.—The makers construct several forms of hollow concrete floor without centering, as well as variations in which terra-cotta is used, and also the solid type of floor necessitating centering. These latter are, of course, beyond the scope of our present article, but the fact that this Company makes them also illustrates their catholicity of view with regard to floor construction.

In *Fig.* 11 we show one of their hollow floors which produces a similar result to the Siegwart floor, but by simpler means. The tubes are, so to speak, split tubes or beams approximately of I-section, which when placed side by side and jointed form tubes. These beams are reinforced by rods, in the bottom flange of which the middle ones are turned up near the ends of the beams, and traverse the web so as to afford resistance to shearing stress. In this variety of floor, as can be seen from *Fig.* 11, the reinforced beams or split tubes run at right angles to the main supports, whether these be rolled steel joists or cross walls in the case of short spans.

In *Fig.* 12 can be seen another form made by this Company, in which the lintels alone are reinforced, and these are shaped with two skewbacks on each side, on which are laid concrete tiles at bottom and top so as to form hollow tubes with the lintels for their sides. This is a convenient form to adopt when it is desired to use the tubes for electric wires, gaspipes, ventilation, etc.

In *Fig.* 13 yet another variety may be seen. In this the reinforced lintels run from one support to the next, and being rebated receive between them complete hollow tubes.

Both the Somerville and United Kingdom floors have not yet been under official fire test in this country, but if due care be taken to protect the metal work, there seems no reason why they should not obtain classification as fire-resisting. The United Kingdom Floor has recently carried out some private load tests, to which we refer elsewhere in this issue.

The Visintini Floor.—A type of reinforced concrete hollow floor, constructed without centering, distinctly different from those we have already considered, is the Visintini system, in which both the hollow beams and the supporting girders are constructed as lattice trussed beams of reinforced concrete. Illustrations and a description of some of the works in which this system is adopted have been given in our issue for September, 1907 (Vol. II., No. 4), page 267, *et sequitur.* The result of a test by the British Fire Prevention Committee of a floor on this system is summarised in our issue of March, 1907 (Vol. II., No. 1), pages 15 and 21. It showed a collapse within two hours on a 10 ft. span only, which was a forcible instance of what results if proper precautions are not taken.

NEW USES FOR CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented as to new uses to which concrete and reinforced concrete are put, with data as to experience obtained during the experimental stage of such new applications of these materials. The use of reinforced concrete as a substitute for timber in exposed positions is one of the questions of the moment. Railway sleepers, telegraph posts, fence posts, etc., of concrete are being tried. Similarly, efforts are at present being made to prove that reinforced concrete is an excellent substitute for brickwork, where structures of great height are required.—ED.

REINFORCED CONCRETE RAILWAY SLEEPERS.

IN our issue of March last we published some interesting photographs of reinforced concrete barges and pontoons, constructed by Messrs. Gabellini, of Rome.

This enterprising firm, who may be deemed to be among the leading reinforced concrete specialists in Italy, now inform us that they have secured an order for 60,000 reinforced concrete railway sleepers for the Italian State Railways, and if we understand rightly, this interesting order is part of a series of orders aggregating to 300,000 railway sleepers which the Italian Government are having made for various railways in different parts of the country.

It will be recollected that we have on a previous occasion dealt with some of the railway sleepers that were made for the Italian Government some years back. Messrs. Gabellini now inform us that the older form, of which they made some five to six thousand about five years back, and which were placed on the lines from Ancona to Castellamare Adriatico, has been slightly superseded in the new design, inasmuch as the rods used for the reinforcement are of a lesser section, but more numerous. This slight change in design is apparently based on the experience obtained in connection with the railway line already mentioned, which is used by a considerable number of express trains, amongst them, it is interesting to note for readers in this country, being the Indian mail to and from Brindisi.

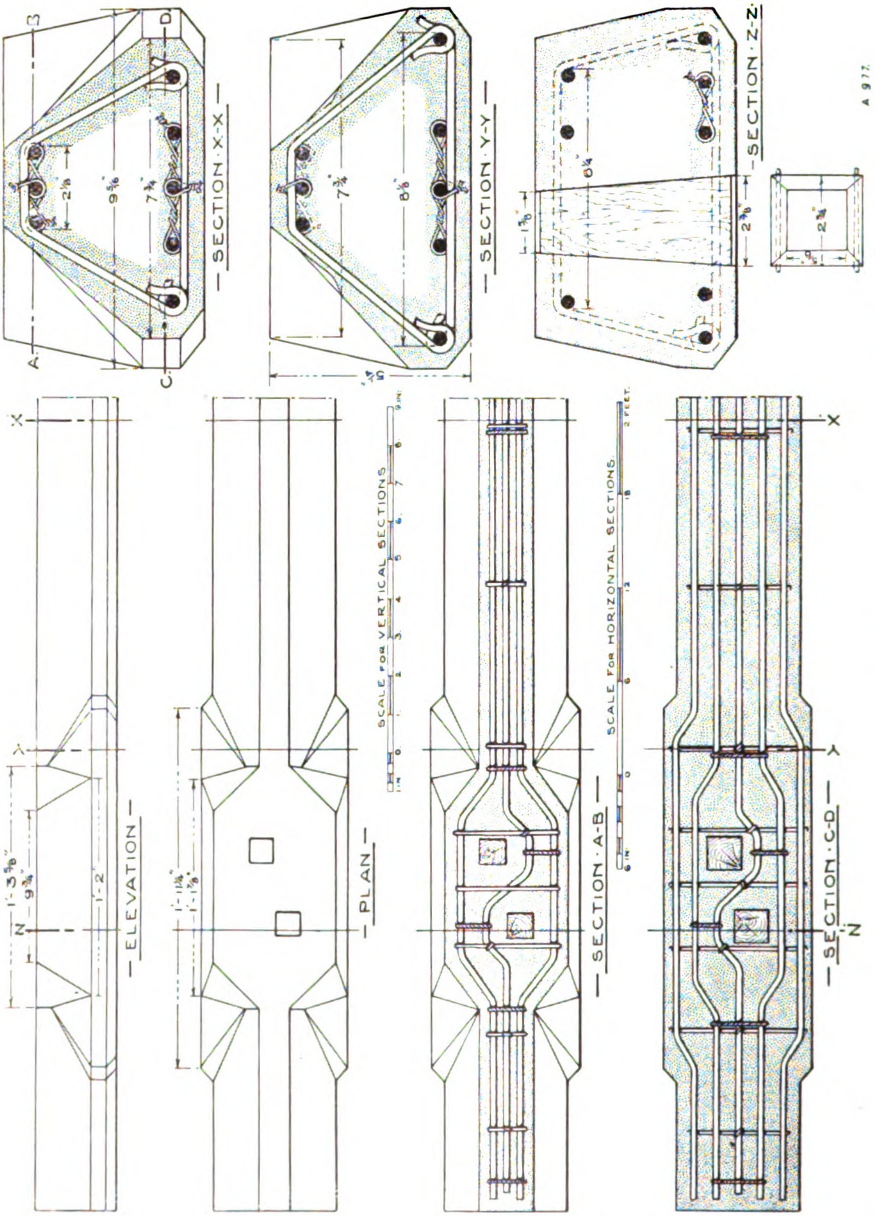
The weight of a sleeper is about 130 kg. (287 lb.), and each sleeper has about 13 kg. (29 lb.) of metal reinforcement. The concrete used is composed of about 750 kg. (1,654 lb.) of Portland cement to every cubic metre of gravel and sand.

The drawings presented give the detail of the sleepers from every point of view, and we would only add that the four wooden blocks used for fixing the rails are creosoted.

As to cost, it would appear that the cost of a sleeper works out at about 6s. 8d., which is a favourable figure for Italy, where the timber required as a rule is somewhat expensive, and, of course, it must not be forgotten that the lasting power of reinforced concrete sleepers is far greater in a hot country such as Italy than timber sleepers, and that though the maintenance question is materially affected by the application of this form of sleeper it is generally anticipated that the life of a reinforced concrete sleeper will be at least three times that of a timber sleeper.

As to the cost of production of such a sleeper in this country, we have not got sufficient data before us, but given the right selection of locality in the neighbourhood of Portland cement works and gravel the cost should also be favourable. We believe that the cost of timber sleepers on our southern railways is between 4s. 6d. and 4s. 9d. (including inspection, testing and creosoting). It would be easy to gauge what the saving would be in this country, even if the reinforced concrete sleeper were as expensive to produce as in Italy, for apart from the actual question of the cost of a sleeper that has to be so frequently reinstated as a timber sleeper there is the very serious question of the labour involved and other expenses incurred in changing the sleepers.

As to Messrs. Gabellini's work, we are informed that they turn out 50 sleepers per day, and will shortly be re-arranging their plant so as to be able to turn out 300 per day.



DETAILS OF THE 60,000 REINFORCED CONCRETE RAILWAY SLEEPERS, WHICH ARE BEING MANUFACTURED BY MESSRS. GABELLINI, OF ROME, FOR THE ITALIAN GOVERNMENT.

From all sides in Italy we hear that there can be no doubt that the experience with this type of sleeper has been most favourable, and it is anticipated that eventually the timber sleeper will be entirely superseded by sleepers of reinforced concrete.

TESTS WITH CONCRETE

AT HOME AND ABROAD.

We consider that the absence of reliable information as to the various tests carried out with concrete both at home and abroad has frequently led to misconceptions as to the qualities of this material, and we shall thus for the present accord considerable space to the presentation of authentic data that may be of service to those employing concrete in its various forms. The tests which will particularly call for our attention are those relating to strength, fire-resistance, and waterproofing.—ED.

TESTS WITH PORTLAND CEMENT MORTARS.

Some Results of the Investigations conducted under the auspices of the United States Government.

A BULLETIN has been issued by the Technologic Branch of the United States Geological Survey on "Portland Cement Mortars and their Constituent Materials," giving the result of 25,000 tests at the Structural Material Laboratories of the Government at St. Louis, U.S.A. The author of the bulletin is Mr. Richard L. Humphrey, engineer in charge of structural material investigations.

The records reported are based on 25,000 tests extending over more than one year of active field and laboratory work. The report may be divided into two parts: the first dealing with tensile, compressive, and other tests, including chemical analyses of Portland cement of different brands donated for the purpose, and of the mortars mixed therewith in which a standard sand was used; the second dealing with tests of mortars prepared by mixing typical Portland cement with 22 sands, 12 gravel screenings, and 25 stone screenings, procured from different parts of the United States, and mixed in different proportions.

In order that tests extending over a period of years might be made with a relatively uniform cement, a quantity of Portland cement of seven different brands was obtained by donation. The extraordinary procedure was adopted of mixing together an equal amount of each of these brands to form an "average" Portland cement (*sic*), and the mixture was stored away in air-tight cans. Tests, made to determine the quality and variation of this "average" or typical Portland cement, were conducted in great detail both on the neat individual brands and the mix and on 1·3 cement mortars made therefrom with standard sand.

The results of the tests showing variation in tensile strength with age of neat cement indicate clearly that the typical mix reached maximum tensile strength in ninety days, or at the same period at which this strength was reached by the separate brands; that it maintained the highest tensile strength for a period as long as that of the best of the individual brands—viz., to 180 days—and that the diminution in tensile strength thereafter to one year and beyond was less than for some brands and no greater than for the best.

The tests of the standard-sand mortars showed maximum strength of the mix at ninety days, or about the same as for the individual brands; more rapid falling off in tensile strength for the mix, up to 180 days, than for the individual brands, but an actual gain in strength beyond the 180 days for the mix, as compared with a falling off of the separate brands.

In the compressive tests the typical mix showed a rapid rise in strength, as did the individual brands up to ninety days, and a less rapid but continual increase in compressive strength to the 360-day period for the mix as compared with some of the brands, four of which showed little or no gain in compressive strength after 180 days.

Compressive tests of the 1·3 standard-sand mortars showed a more rapid gain up to 180 days for the typical mix than for the separate cement brands, and continued increase in compressive strength beyond 180 days for the mix, as against a less ratio of increase for several of the individual brands tested.

A study of the percentage of gain in strength exhibited by the various cements and cement mortars tested shows the very important fact that, though the cements may test low or high at seven days, and though there may be varying percentages of increase during the four periods from seven days to one year, yet after the 180-day and the 360-day tests the strengths of all the standard-sand mortars were reasonably close one to another This indicates that early strengths may vary considerably without seriously affecting the later strength of the cement or mortar.

The purpose of the investigations of the constituent materials of mortar was to ascertain as far as possible the properties of such materials collected in different parts of the United States. It is believed that the results of these tests made on material obtained near the large commercial centres of the country will indicate clearly to users of cement and of concrete where they may most conveniently and cheaply procure the requisite sand, gravel, etc., and how these should be mixed to attain the best result in tensile or compressive strength for each group of constituent materials.

A study of the data in this part of the report should afford a means of determining the probable strength of mortar made from materials having similar properties, though gathered in different parts of the country, and should aid the constructor to decide which of three materials—sand, gravel, or broken stone screenings—will best serve his purpose.

The tests whose results are here presented were made on mortars, using different proportions of the typical Portland cement and sands, gravel screenings, and stone screenings collected in various parts of the country, the properties of which are discussed in the earlier part of the bulletin. The report describes the material, the locality of its occurrence, and the methods of screening, grading, etc., employed. The relative proportion of larger or smaller particles in the materials tested is not only described in detail and diagrammatically, but is well illustrated by reproductions of photographs made to exact scale.

Considering these tests in respect to the percentage of voids, it appears that the tensile strength decreases with the increase of void spaces. The strength of the mortars is invariably much greater when made from sands having a small percentage of voids than when made from sands having a large percentage. The strength of mortars of different proportions is also greater for those sands which have a small percentage of voids. This condition is the same in regard to both tensile strength and compressive strength, and indicates that the greatest strength can be obtained by the use of mortar in which the sand is uniformly graded. The same is true of tests of transverse strength, except that the difference is not so marked as in the tensile and compressive tests.

The tests show a greater uniformity in general when made at the end of 180 days than when made for shorter periods. The early strength appears to be easily affected by alteration in environment, and the regularity in strength for the earlier periods appears to depend on the nature of the cement.

In tests of density of mortar, it appears that the density values are greatest for the least percentage of voids, and that the weight per cubic foot and the strength are greatest under the same conditions. In the tests of mortars made with gravel screenings, only that material which passed a ¼-in. screen was used, and this amounted, as a rule, to less than 40 per cent. of the sample received at the laboratory. As in the description of tests of mortars made with sand, complete details are given of the diameter of the particles in inches, with number of sieves passed, of the place in which samples were taken, and of physical and chemical tests. In these tests there is apparently a greater lack of uniformity in the increase of strength, probably owing to physical differences in the gravel screenings. In general the tensile strength seems to increase with the decrease in percentage of voids. This is also true of the compressive strength.

The tests are a splendid record of systematic work, but much of their utility is discounted by the initial error of policy in creating a mixing of various brands of Portland cement, a condition of affairs entirely unreal and inviting chemical features entirely strange to the initial question under investigation. No doubt the mix was intended to overcome friction or trade jealousy, but that is no reason for testing under unreal conditions.

TEST OF A FLOOR OF LARGE SPAN.

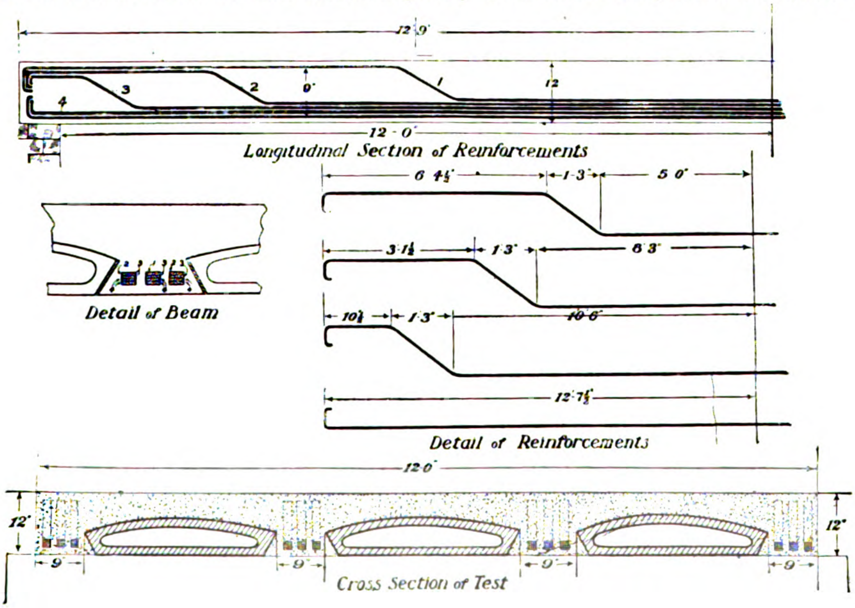
An experimental test was carried out recently by the United Kingdom Fireproofing Co., Ltd., at their works at Alperton, on a reinforced concrete floor of 24 ft. clear span. Floors of such span are seldom constructed, and we do not recollect many tests in this country of such a span. The floor was intended to represent a hospital ward floor, 24ft. clear span, and 12 in. deep, constructed without rolled steel joists. The floor was constructed on the hollow-block system of 24 ft. clear span, the slab being 12 ft. wide.

Two floor slabs, as a matter of fact, had been constructed at the Works, one being used for a preliminary test, the distributed load applied being stated to be about 85,000 lb. This load had been on the floor for over a month and caused some deflection, but on being removed in the presence of visitors nearly all the deflection was recovered.

Both floors were constructed in the last week of December, 1907, and thus when the principal test took place with the second floor, setting time was just over three months.

The floor was made of granite concrete, proportioned 4 parts crushed Leicestershire granite, 1 part sharp sand, and 1 part Portland cement; this latter was of the "Ferrocrete" brand, supplied by the Associated Portland Cement Manufacturers. The tubes were of concrete similar to the fill and measured 3 ft. wide by 7 to 7½ in. deep and 12 in. long, their thickness varying between 1¾ and 2 in. The floor rested upon blue-brick piers, well strutted to prevent overturning. The section of each reinforcing rod was 1¾ in. × ¼ in., so that the total section of metal in each beam was 5¼ sq. in. The rods were of flat section, as shown, and of mild steel obtained from stock, having a tensile strength of about 28 tons ultimate, and an elastic limit of about 18 tons. The reinforcements were cranked up as shown at different places as the supports were approached so as to resist diagonal tension stresses (or as they are often incorrectly termed, shear stresses), which are considerable under a distributed load with such a wide span as this. The floor was designed to carry a superimposed load of ¾ cwt., with a factor of safety of 4. The floor was given 1 in. camber, and the centering consisted of boards strutted from below placed under the beams only, the tubes between these boards forming a permanent centering. The tubes were below the neutral axis of the floor and consequently in the tensile area, and in the calculations were not assumed to afford any strength, though they provided, of course, lateral support to the beams. The real construction sustaining the load was obviously of T-beam form.

THE FLOOR UNDER TEST.



Longitudinal Section of Reinforcements

Detail of Beam

Detail of Reinforcements

Cross Section of Test

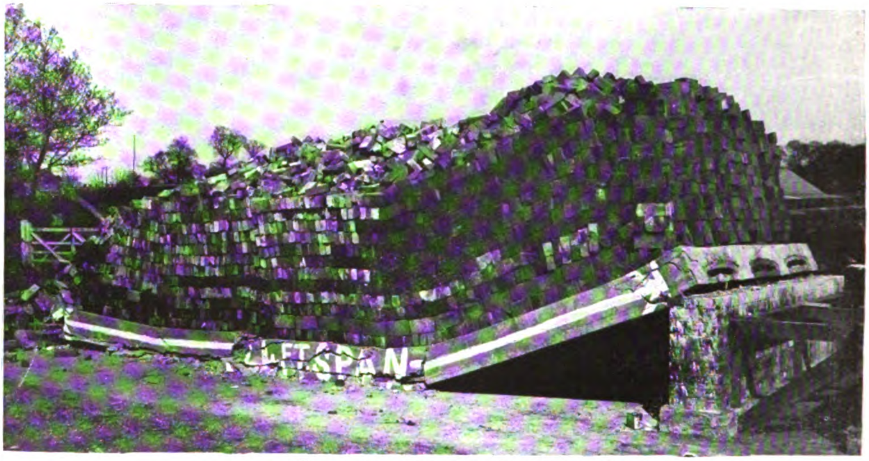
GENERAL DETAILS OF FLOOR TESTED.

The deflection was read on a sliding scale as each layer of bricks comprising the load was applied. The bricks of the load varied in weight, but we took care to determine the load fairly closely. The load was at first carried out on a centre strip 7 ft. 6 in. wide across the clear span, this being done with the idea of testing only the 7 ft. 6 in. strip of floor; but, as it was obvious that the unloaded side pieces (which had been constructed with the idea of supporting the loaded strip as would occur in a continuous floor, *i.e.*, like the abutting portions of a continuous floor) were in reality taking up a considerable portion of the load, although their deflection was slightly less than in the middle under the load, it was decided eventually to load the entire area of the floor.

The following table gives the deflection measured at various stages of the loading:—

Total Load Distributed. Lbs.	Centre Deflection at middle. Inches.	Centre Deflection at sides. Inches.
8,000	$\frac{1}{8}$	$\frac{1}{8}$
16,000	$\frac{3}{16}$	$\frac{3}{16}$
24,000	$\frac{1}{4}$ bare	$\frac{1}{4}$ bare
32,000	$\frac{5}{16}$	$\frac{5}{16}$
40,000	$\frac{7}{16}$	$\frac{13}{32}$
47,600	$\frac{9}{16}$	$\frac{17}{32}$
55,200	$\frac{11}{16}$	$\frac{5}{8}$
62,800	$\frac{7}{8}$	$\frac{3}{4}$
70,400	1	$\frac{7}{8}$
78,000	$1\frac{1}{8}$	1
85,600	$1\frac{5}{16}$	$1\frac{1}{8}$
93,000	$1\frac{1}{2}$	$1\frac{3}{16}$

The loading was now conducted on the side portions, which had not been previously covered with bricks, to the height of 12 courses, to which the middle portion had been carried. The total load on the floor at this point was 127,500 lb., the deflection in the middle being $2\frac{1}{4}$ in., and the deflection at the sides 2 in. Bricks were now thrown on the centre without any attempt at stacking, the deflection gradually increasing up to $3\frac{3}{16}$ in. in the middle and $2\frac{7}{8}$ in. at the sides, when the total quantity of bricks available had been placed upon the floor, weighing in all about 72 tons. The floor broke down several hours later under this same load. A certain amount of arching occurred in the load, but the bricks were stacked in such a manner that the layers did not bond very much with each other, and to a great extent the load was properly distributed. The side beams were, of course, practically half beams, and consequently they were over-reinforced, this probably accounting for the fact that they did not deflect so much as the middle beams.



THE FLOOR AFTER THE COLLAPSE.

From an approximate calculation we find that the stress in the steel was about 15 tons per sq. in., and the maximum stress in the concrete 2,000 lb. per sq. in. under the total load of 72 tons. Taking the whole of the floor, it sustained a load without breaking of about 680 lb. per sq. ft., including its own dead weight of 120 lb. per ft. super. This provided a factor of safety of $3\frac{1}{3}$ on the dead and superimposed loads combined, or $6\frac{3}{4}$ on the live load alone, and this may be considered satisfactory.

Some diagonal cracks were developed near the supports, but the shear reinforcements did their intended work satisfactorily. Cracks developed on the soffit of each of the beams, but these were not at all wide.

EXPERIMENTS AT THE NATIONAL PHYSICAL LABORATORY.

At the request of Sir John Brunner, some tests were undertaken "On the Effect Produced on Samples of Mild Steel Embedded in Concrete," and the following is the official report of these experiments:—"A strong wooden box was made and divided into five partitions, each partition being 12 in. long, $7\frac{1}{2}$ in. wide, and $7\frac{1}{2}$ in. deep. Specimens of mild steel of the following dimensions were prepared: (1) One inch diameter, 8 in. long, turned all over. (2) Eight inch lengths cut from a $1\frac{1}{2}$-in. by $1\frac{1}{2}$-in. bar with the scale left on. The partitions were half-filled with good Portland cement concrete and a specimen of each kind laid on the top, and the partitions were then filled up. This was done on December 21st, 1906. The blocks were covered with water several times a week for a year, and for three months afterwards were left in the open subject to the weather. On April 20th one of the blocks was removed from the box and broken up, and the specimens removed. On examining the specimens carefully no trace of any action by the cement could be detected. The turned specimen was practically as bright as when it was put in, and the scale on the rough specimen was undisturbed. To test the possibility of any slight action the surface of the turned specimen was polished and etched and examined under the microscope side by side with a specimen of the same material cut from the centre of the bar. No difference in the micro-structure of the two specimens could be detected, and the conclusion is that in 16 months no action has taken place between the metal and the concrete. It is proposed to immerse one of the remaining blocks in the comparatively warm water of the cooling pond for six months and then to examine the specimens."

NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

UNDERPINNING WEST PIER, NEWHAVEN.

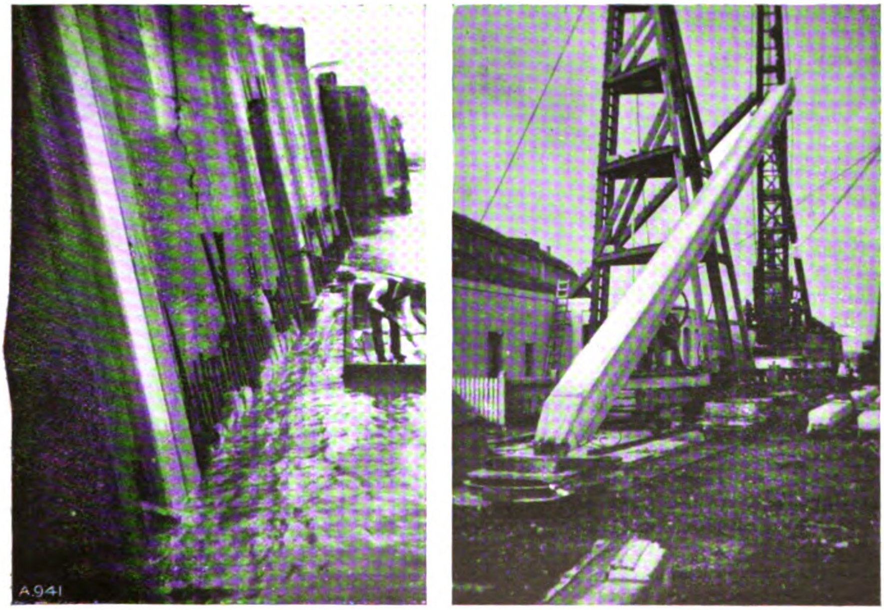
THIS work is for the London, Brighton & South Coast Railway, and is under the supervision of Mr. Charles Morgan, M.Inst.C.E., Engineer-in-Chief to the Company. The contractors for the Coignet system, which was applied on this work, were Messrs. W. Hill & Co., of London.

It was necessary to replace the old wooden piles supporting the work on account of the decayed condition of the wood, which had been attacked by Limnoria. The piles, which number some 600, and should be more accurately described in this case as "sheet piles," contained a framework of four principal bars of angular section as reinforcement, the latter being strongly bound together by flat iron pieces and the entire framework further bound with wire.

The concreting operation was carried out in a horizontal mould. The shape of the piles was such as to allow them to be grooved into each other. The length of the piles is variable, the longest measuring 52 ft., and the scantling is 16 in. by 16 in.

One of the illustrations shows a pile, 52 ft. long, and weighing about 6 tons, being lifted by one end to an angle of about 35 degrees. The deflection in the middle was about ½ in. This proves distinctly that reinforced concrete piles can be made to resist considerable side thrusts.

The driving apparatus consisted of a steam pile driver with a monkey weighing 2 tons, which struck a wooden dolly resting on the head of the pile.



Side of Pier.

A Pile.

REINFORCED CONCRETE UNDERPINNING OF THE WEST PIER, NEWHAVEN.

THAMES HAVEN.

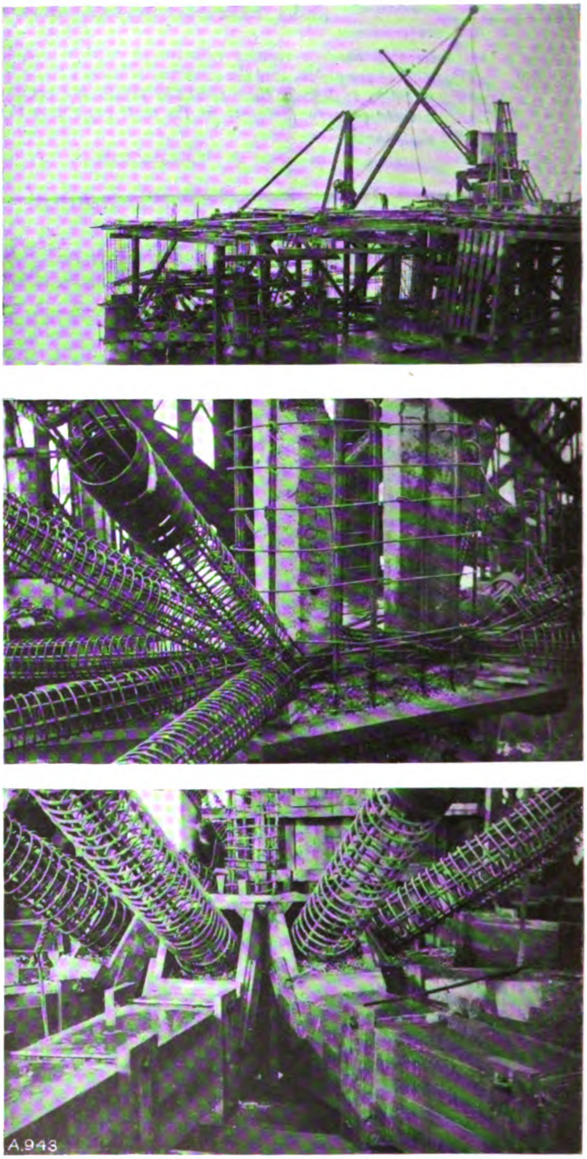
The reconstruction of the T-head of the jetty at Thames Haven for the London and Thames Oil Wharves, Ltd., has been undertaken owing to the necessity for replacing the old structure.

The deck of the jetty is 45 ft. to 48 ft. from the bed of the river, and stands in about 23 ft. of water at low tide, and about 40 ft. of water at high tide.

The main supports are composed of two 15 in. octagonal Considère piles, driven 20 ft. into the bed of the river. These piles are enclosed by a circular block of concrete 5 ft. dia., up to low water level, above which this cylinder is reduced into an oval shape of 5 ft. by 2 ft. 6 in., and carried up to deck level. These columns are constructed below low water level by the use of a temporary steel cylinder, made in two halves, and lowered over the piles on to the bed of the river, into which they are sunk 2 ft. to 3 ft. The reinforcement is then placed inside and the concrete filled in through the water by means of timber shoots, and the cases are removed when the concrete is set.

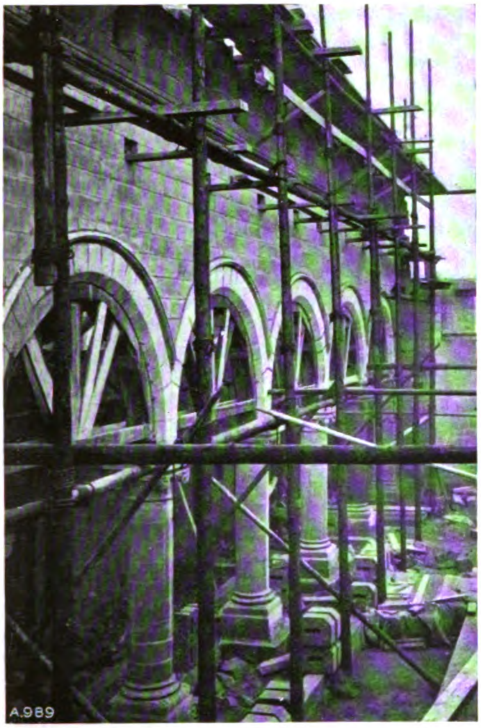
The structure is heavily braced from low water level up to deck level, the bracings and wallings being built up by the usual shuttering.

The piles penetrate well into the Thames ballast, which is just underneath a top layer of mud, and in every case have been driven until they have practically refused to drive any further. The final penetration set has varied from 40 to over 100 blows for the last inch. Some of the piles have been driven with the monkey striking direct on to the head, and on others a timber dolly has been interposed. No cushion or cap, however, for relieving the blow has been used.



Reinforced Concrete Jetty at Thames Haven.

A small portion of the old jetty was left undamaged by the collision, and traffic is being kept working alongside this during the construction of the first half of the new head. This will shortly be finished, and traffic will then be diverted on to the new half of the structure pending the completion of the remainder.



HOLLOW CONCRETE BLOCK CHURCH AT SUNDERLAND.
In course of construction.

A CONCRETE BLOCK CHURCH.

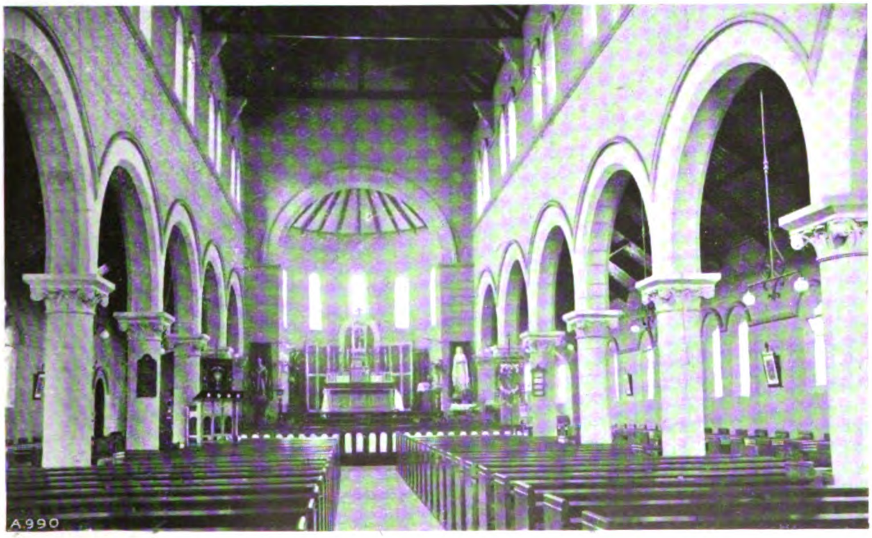
Two churches constructed entirely of moulded concrete blocks have been erected at Sunderland and Seaham Harbour, in the county of Durham, being the first of their kind in Great Britain. No stone or brick has been used in any part of the work. The success of concrete blockwork for such class of buildings in this country has been established, and engineers and architects who have travelled many miles to inspect the work have decided to recommend its use for similar structures, especially where cost is a consideration.

The outside faces of main walling have rusticated blocks with drafted margins, and the ashlar on the moulded jambs and dressings has a plain, rubbed face.

The interior walls are faced with plain ashlar faced blocks, and are jointed and pointed similar to stonework. There is no plastering in any part of the buildings.

The carved caps of the nave arcades are cast solid, and fixed just as they leave the moulds. This is a novel feature, as caps of cast work are usually put together in sections.

The whole of the blocks were made on Pioneer machines on the site, by workmen selected from the intelligent



INTERIOR OF HOLLOW CONCRETE BLOCK CHURCH AT SUNDERLAND.

labouring class, skilled labour only being required for fixing. The material used was fine crushed whinstone chippings, clean, sharp sand, and Portland cement in the proportion of five, three, and two, and this was found to produce a first-class block, clean and hard, and of a colour similar to that of Portland stone.

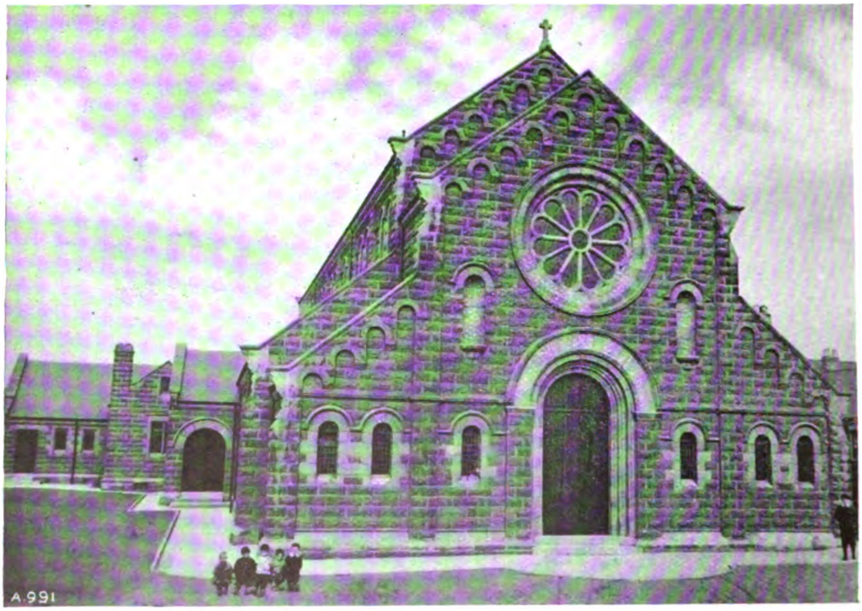
The ordinary building blocks, which are hollow, are 2 ft. 8 in. long, from 10 in. on the bed, and 9 in. high, and three men and a lad can make 120 blocks a day on one machine. All blocks are made on the semi-dry process, only a sufficient measured amount of water being used to allow of the material being properly rammed in the machine; on leaving the latter they are placed on racks for curing and kept wet until thoroughly set. They are fit for the fixers in about three weeks.

The cost of the blockwork and the time occupied in building has been about half that of stone, and of the lasting qualities there can be no doubt.

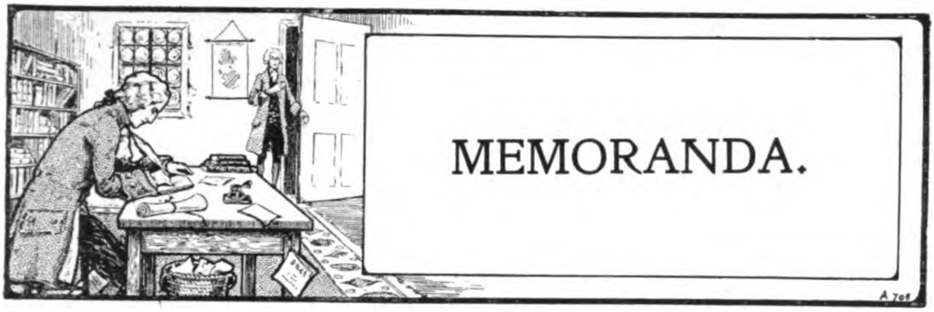
During the erection of the building a severe frost set in, which lasted about a fortnight, then came a thaw and snow, followed again by frost. During this time the walls and blocks on the site were left totally uncovered, no protection of any sort being afforded. When the weather became favourable for restarting the work the men proceeded straight away with the building, as not a block was found to be affected in the slightest.

The introduction of concrete blockwork for these churches was due to Mr. Thos. Axtell, an engineer, of Sunderland, who was also responsible for the designs, and the work was carried out under his personal supervision. The churches have been open since the end of last year.

Concrete blockwork is suitable for any class of building, and the saving in cost and time is considerable even over ordinary brickwork. Given sufficient room, and other conditions being favourable, Mr. Axtell (to whom we are indebted for our illustrations and data) informs us that he could erect substantially built cottages and other buildings with concrete block at an exceptionally rapid rate, as it is only a question of laying down sufficient machines to produce the blocks and keeping smartly ahead with the materials.



Exterior of Hollow Concrete Block Church at Sunderland



MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Question and Reply in the House of Commons regarding Reinforced Concrete Buildings.—Sir F. Dixon-Hartland, M.P., recently put a question in the House of Commons on matters relating to the use of reinforced concrete in public buildings. Question and reply are as follows :—

Question.	*Reply of the First Commissioner of Works (Mr. L. Harcourt).*
If in view of the Milan disaster, resulting in serious loss of life from the failure of the reinforced concrete, he intended still going on with the use of a similar system of construction at the National Gallery extensions and other buildings; and whether he would consider the advisability, in the national interest, of causing competitive and comparative tests to be made of the different systems of fire-resisting construction before proceeding further with the work?	*So far as my present information goes about the accident at Milan, there is nothing in it which makes me hesitate to employ the best systems of building in reinforced concrete, both at the National Gallery and elsewhere. Tests of various forms of fire-resisting construction have been made by the British Fire Prevention Committee, and I do not see that any useful purpose will be served by repeating them.*

In reply to a further question by Sir F. Dixon-Hartland, the First Commissioner of Works said :—

He believed that the accident at Milan took place during the preliminary tests, which was a likely time at which defective construction would be discovered.

Belgian Portland Cement and Government Contracts.—The following question was recently put in the House of Commons to the Postmaster-General by Mr. Whitehead, M.P. for East Essex :—

Question.	*Reply by the Postmaster-General (Mr. Sydney Buxton).*
Whether Belgian natural cement is being used for work in connection with the Post Office at Kingston-on-Thames; whether he was aware that this article does not comply with the British standard, or any other specification used for genuine Portland cement, and is of inferior quality; and whether he could see his way to issue instructions that works under his Department should adopt the British standard specification in accordance with the practice of other Departments?	*The contract for this work (as in all other contracts of the kind) provides that Portland cement of the best quality shall be used. A test of the cement in this case showed that this provision was not complied with, but I am unable to ascertain whether the cement used was or was not Belgian cement. I am considering what further steps shall be taken in the matter.*

LECTURES.

Papers on Reinforced Concrete.—An interesting lecture was delivered at the meeting of the North Wales Sanitary Inspectors' Association, held at Rhyl at the end of May, on the subject of Reinforced Concrete Work, by Mr. Harry Burke, C.E. Mr. Burke gave some interesting particulars on the subject of stresses. The reinforced concrete Pavilion at Rhyl was inspected by the Association, the work being in course of construction. The architects are Messrs. Maxwell & Tuke and F. B. Smith.

An interesting paper on concrete and reinforced concrete generally was presented by Mr. E. P. Wells, C.E., to the Incorporated Clerks of Works Association of Great Britain, and which contained a large number of practical hints.

Papers on the Sewage Works in Progress at Norwich.—An interesting paper is that recently read by Mr. Arthur E. Collins, M.Inst.C.E., City Engineer, Norwich, before a meeting of the Incorporated Association of Municipal and County Engineers. A great deal of reinforced concrete is being used for sewage work in Norwich, and we hope to be in a position to publish some interesting details and illustrations at an early date.

Paper on Concrete Viaducts. — A paper recently issued by the Institution of Civil Engineers, to which we would like to call attention, is one by Mr. Walter Stuart Wilson, M.Inst.C.E., on "The Concrete Viaducts of the West Highland Railway." The paper deals with the Glenfinnan viaduct of 21 spans of 50 ft., and the Borrodale viaduct comprising a central span of 127 ft. and two other minor spans. Both instances are of block concrete, and the illustrations presented show that the works are of some engineering importance.

Glenfinnan Viaduct (Constructed of Block Concrete).

VARIOUS.

Protective Action of Concrete on Iron.—It is pointed out that the fact that iron and steel when embedded in concrete are almost wholly protected against rust is somewhat difficult at first sight to explain, since it might reasonably be expected that the metal would be exposed to oxydation, and this would bring about the speedy disintegration of the mass. Dr. Rohland, in discussing this question in *Stahl und Eisen* for January 29, shows that this freedom from oxydation is probably due to physico-chemical causes which prevail during the setting process of the cement and in the early stages of induration. In the first place the lime present in solid solution in the mass combines with water, but then the colloidal aluminium oxide together with the colloidal iron hydroxide and the colloidal silicium oxide are separated from the mortar and are gradually coagulated by means of the hydroxyl ions. These coagulated substances act much in the same way as a varnish or film, and thus prevent a further penetration of the water into the interior of the cement. By this means a protective action on the iron surfaces against the influence of the oxygen of the air and of the water is secured and the formation of rust is prevented.

To Brighten a Concrete Floor.—We understand that a cheap wash to put on a concrete floor to allay dust may be made by heating a penny bottle of gum in a small tin, with as much ground borax and alum added as would lie on a threepenny bit. Of course, only enough may be added at a time to suit the amount of wash used. A little experimenting will soon set the quantity right, and colour may be put in as desired.

A Reinforced Concrete Theatre.—A theatre has now been completed in reinforced concrete at Agen in France, from the plans of M. Guillaume Tronchet, of Paris. It has a seating capacity of 1,000, and was erected in the short time of eleven months. There are no columns in the interior, and large staircases have been built to allow of safe exit in case of a panic. The building is as fire-resisting as it is possible to build it, and the acoustic properties have been found most satisfactory.

MEMORANDUM.

Of the illustrations kindly put at our disposal relating to the Stadium at the Franco-British Exhibition the two photographs reproduced on pages 117 and 120 were taken by Mr. F. N. Birkett, of Shepherd's Bush, and were the property of Messrs. Alex Findlay & Co., of Motherwell, who carried out the structural work, and who lent them to the Empire Stone Co., Ltd., for publication. We desire to express our acknowledgments to photographer and owner. We were not aware at the time of publication that Messrs. Findlay were the owners of the two photographs.

CONTRACTS, Etc.

Considère Construction Co., Ltd.—The Cubitt Concrete Construction Co. have just finished a small contract at Westferry Road, Millwall, in which the Considère system has been applied.

The works consisted of foundations for schools, and were composed of an armoured concrete raft carried on piles. The piles were 22 ft. long and of octagonal section, 13 in. dia. across flats, and were spirally reinforced on the Considère principle with 12 lb. of steel per lin. ft. The raft was composed of beams spanning from pile to pile, with a 6 in. deck covering the whole area.

The piles were all driven with a 30 cwt. monkey with a 4 ft. drop, and finished at a penetration of 1 in. to 10 blows. It is interesting to note that none were broken in the driving.

The architects for the work were Messrs. R. L. Curtis & Son.

Reconstruction of Southampton Harbour Jetty.—We understand that the Harbour Board have accepted the tender of Messrs. Robert H. B. Neal, Ltd. (licensees for the Hennebique system), for the reconstruction of the above jetty. Messrs. Neal have carried out similar work in the district.

Messrs. Owens & Case.—Messrs. Mouchel & Partners, Ltd., have purchased the patent rights of Messrs. Owens & Case in connection with reinforced concrete groynes, enabling them to deal with any coast erosion schemes. This form of construction for coast protection works is claimed to be of great value.

CHANGE OF ADDRESS.

The offices of the Associated Portland Cement Manufacturers (1900), Ltd., have been moved from Dixon House, Fenchurch Street, E.C., to Portland House, Lloyd's Avenue, London, E.C.

CATALOGUES.

Ransome-verMehr Machinery Co.—We have received from this Company an interesting catalogue of the Ransome Concrete Mixers, well described and fully illustrated. In addition to a comprehensive table giving the capacities and dimensions of the mixers, there is an excellent set of drawings at the end of the booklet.

The British Reinforced Concrete Engineering Co. have sent us a quarto pamphlet of some 70 pages which they have issued. Some of the examples of work executed are of considerable interest, and a most useful appendix has been added, giving the full text of the Report of the Committee on Reinforced Concrete.

NEW BOOKS

AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the past year.

SOME FOREIGN BOOKS ON REINFORCED CONCRETE.

TWO AMERICAN BOOKS.

Principles of Reinforced Concrete Construction. By F. E. Turneaure, *Dean of the College of Engineering, University of Wisconsin,* **and E. R. Maurer,** *Professor of Mechanics, University of Wisconsin.*

Published by John Wiley & Sons, New York; Chapman & Hall, Ltd., London, 1907.

Contents: Introduction.—Properties of the Material.—General Theory.—Tests of Beams and Columns.—Working Stresses and General Constructive Details.—Formulæ.—Diagrams and Tables. — Building Construction. — Arches. — Retaining Walls and Dams.—Miscellaneous Structures.

This, one of the latest American works on the subject, will probably be found one of the most useful by those who have to undertake constructions in reinforced concrete, and require to know how to make the necessary calculations of stress.

The composition and preparation of concrete are first briefly treated, and an interesting short section follows on its elastic properties, based mainly on experiments made in Wisconsin University. The value of 2,500,000 lb. per sq. in. is obtained for the modulus of elasticity, and it is concluded that the maximum load which may be repeated an indefinite number of times without rupture does not greatly exceed 50 per cent. of the ultimate strength of the concrete. The stresses due to the contraction or expansion of concrete in which steel reinforcing rods are embedded are also considered.

A short account is given of the general theory of members subjected to flexure, and the modifications of the theory which become necessary when applied to concrete are then considered. Throughout the book full use is made of graphical methods, and there can be no doubt that such graphical diagrams will come into general use among constructors. Apart from the saving of time which they involve, graphical methods afford less risk of error than the somewhat complicated mathematical formulæ which have otherwise to be employed.

The next chapter deals with the mode of failure of concrete beams, illustrated by photographs of beams broken in the testing machine, and the results are then utilised to determine the most suitable arrangement of the web reinforcement. Hooped columns are also considered. The short section on fire protection might with advantage have been expanded, and reference should have been made to the importance of the nature of the aggregate. The minimum thickness of covering to the reinforcement suggested is also unduly low.

The section containing formulæ and diagrams for use in designing floors and columns is admirably clear. Examples are given, selected from various methods of construction, and attention may be called to the interesting diagrams and calculations for the so-called "mushroom" system of connecting floor-slabs with columns without the use of beams, a construction which involves somewhat novel mechanical problems, of which a graphical solution is given. The stresses and deflections in arches are considered mathematically, with examples from arched bridge practice, and the book closes with a brief treatment, illustrated with many diagrams, of such miscellaneous structures as girder bridges, retaining walls, dams and culverts.

Profs. Turneaure and Maurer have written a work which should facilitate very greatly the rather tedious operations which are necessary in elaborating the design of reinforced concrete structures.

The Design of Walls, Bins and Grain Elevators. By Milo S. Ketchum, C.E., *Dean of the College of Engineering and Professsor of Civil Engineering, University of Colorado.*

Published by the Engineering News Publishing Co., New York; Arch. Constable & Co., London, 1907.

Contents: The Design of Retaining Walls. — Rankine's Theory. — Coulomb's Theory. — Design of Masonry Retaining Walls.—Reinforced Concrete Retaining Walls.—Experiments on Retaining Walls.—Examples of Retaining Walls.—Cost of Retaining Walls.—Types of Coal Bins, etc.—Stresses in Bins.—Experiments on Pressures on Bin Walls.—The Design of Bins.—Examples and Details of Bins.—Cost of Bins.—Methods of Handling Materials.—Types of Grain Elevators.—Stresses in Grain Bins.—Experiments on the Pressure of Grain in Deep Bins.—The Design of Grain Bins and Elevators.—Examples of Grain Elevators.—Cost of Grain Bins and Elevators.

This book should be of great interest to architects and engineers engaged on industrial buildings, which covers a number of matters where the factory architect and engineer frequently require a usetul reference book. It is a sign of the times that the principal chapter deals with retaining walls of reinforced concrete construction, whilst among the bins and elevators the examples of reinforced concrete work are certainly the more interesting and probably also the more important for modern practice, having regard to the fact that they are generally more economical.

We can strongly recommend the book to our readers.

A FRENCH BOOK.

Typical Construction of Reinforced Concrete Road Bridges. By Messrs. N. de Tedesco and Victor Forestier.

Published by Ch. Béranger, Paris, 1907. 2 vols.

Contents: Official Instructions.—Methods of Calculation for Curved Surface in Reinforced Concrete.—Deformation of Reinforced Concrete Beams. —4 m. Bridge in 1 span.—6 m. Bridge in 2 spans.—8 m. Bridge in 2 spans.—10 m. Bridge in 1 span.—15 m. Bridge in 2 spans.—20 m. Bridge in 1 span.—25 m. Bridge in 2 spans.—30 m. Bridge in 1 span.

This work, one of the latest additions to the *Encyclopédie des Travaux Publics*, is published in the form of an 8vo volume of 300 pages of text, and a 4to atlas of plates. The elaborate instructions of the circular issued on October 20th, 1906, by the Ministry of Public Works, Posts and Telegraphs, are reproduced in full. These ministerial instructions were the outcome of a long investigation, extending over three years, by a special commission, and may be taken as representing the best available knowledge of reinforced concrete bridge construction at the time of issue, but they are in no way to be regarded as final. Hence they are officially entitled "Instructions," and not "Regulations," and engineers engaged in public works are not bound to employ the formulæ there used, if another, having a rational basis, is preferred. The principal differences from the regulations already issued by the Swiss and German authorities consist in the account now taken of transverse reinforcement intended to resist bursting tendencies, and in the fact that the ratio *m.*, which is, theoretically, that of the coefficients of elasticity of steel and concrete, and is usually taken as 10 or 15, is now treated as variable, assuming values between 8 and 15 according to the disposition of the reinforcement.

Taking these instructions as their starting point, the authors give details of the calculations of the dimensions of bridges subject to bending, and of their deformations under load. This part of the book contains the working out of the necessary equations, and is illustrated with many diagrams.

The second, and larger section of the work consists of the detailed designs for eight bridges, varying in length from 4 to 30 m. The full calculations of dimensions are given, and the accompanying atlas contains complete working drawings for each. All the bridges are of the simple girder type, and are neat and effective in design, considerable ingenuity being displayed in some of the details. The reinforcement is in all cases composed of round rods, the upper and lower rods being connected by loops of thinner round rod. Pendariès' graphical method is employed in calculating the position of these transverse loops. The completeness of the treatment, as regards both the computations and the graphical constructions, makes the work an invaluable one to all persons engaged in the design of bridges intended to carry road traffic. It must always be remembered, however, that the strength of light structures of this kind is in a special degree dependent on the quality of the concrete used, and on the care with which the constructional work is carried out, and this point is duly insisted on in the official instructions before mentioned.

The work of Messrs. de Tedesco and Forestier is undoubtedly a most valuable addition to the now extensive literature of reinforced concrete constructional engineering.

TWO GERMAN BOOKS.

Einfluss der Armatur und der Risse im Beton auf die Tragsicherheit.

The Influence of the Reinforcement and of Cracks in Concrete on the Resistance to Load. By E. Probst, *Civil Engineer. Supplement I. to the Reports of the Royal Testing Station at Gross-Lichterfelde, 1907.*

Published by Julius Springer, Berlin, 1907.

Contents: Preparation of Test-pieces.—Determination of Elasticity of Concrete under Tension and Compression. —Determination of Elasticity of Reinforcement.—Experiments on Rectangular Beams.—Effect of Repeated Loading.—Causes of Fracture.—Experiments on the Action of Rust-forming Substances on the Reinforcement after the Appearance of Cracks. —Determination of the Adhesion by Bending Tests.—Comparison of the Results with the Methods of Calculation employed in Germany, America, France and Switzerland.—Methods of Approximation.

The author of this memoir describes a very extensive series of experiments recently carried out in the Berlin Laboratory at the cost of the Expanded Metal & Corrugated Bar Co., of St. Louis. Tests were made on plain and reinforced concrete beams, both round rods and various patterns of twisted, indented and flattened bars being employed. Such deformed bars are found to give better adhesion than plain bars, since in the latter case the first cracks which appear continue to widen, whilst in the former, as the load increases, fine new cracks appear without breaking down the adhesion. The adhesion increases with the age of the concrete. The total extension of a concrete beam before cracking is greater when reinforced than when plain.

Beams which have been allowed to harden under water give a greater extension than these hardened in air, owing to the expansion of volume under water, giving rise to initial tensile stresses in the steel and compressive stresses in the concrete. Stress is laid on the fact that concrete which is mixed too dry is unable to fill the spaces between the reinforcing rods uniformly, and is consequently very liable to give irregular results. A rather wet mixture is therefore to be preferred, although compression tests give lower values for the breaking strength than when a drier mixture is employed.

Exposure to corrosive gases, under more severe conditions than are likely to be met with in practice, except in rare cases, showed that the danger of rusting only appears when the concrete has cracked to such a depth as to expose the iron. This, however, does not occur until the rods have already been strained beyond their elastic limit, that is, when the beam is already on the point of failure. Corrosion by external vapours is therefore an imaginary danger.

By a comparison of the experimental results with the methods of computation prescribed by the different official regulations, it is shown that in the case of beams the Swiss and German methods give a factor of safety of from 2·5 to 3·2, the French method only about 2·0.

There is a great store of useful information, especially as to the way in which the fracture of beams actually occurs, in Mr. Probst's memoir, which is excellently illustrated with diagrams, curves and photographs.

A German Pocket-Book for Concrete Users.

The publishers of the *Tonindustrie-Zeitung* have issued, in two parts, the *Beton Taschenbuch* for 1908. Part I. is in the form of a neat diary, with the addition of matter useful to those engaged in concrete construction. This matter includes the Prussian regulations for reinforced concrete, instructions for the carrying out of ordinary concrete work, cement standards and testing methods, and a series of aphorisms relating to each of the materials used and to their proper employment. There are also several tables, including one which shows the maximum stresses permitted in a number of well-known concrete bridges. The pocket-book is handy in shape, and contains much useful information in a compressed form.

Part II. is a paper-covered pamphlet, containing a brief illustrated account of the various patented methods of construction in plain and reinforced concrete, tables of the weights of reinforcing steel, and lists of books and of commercial firms, which are useful for reference.

Structural Engineering. By A. W. Brightmore, D.Sc., M.Inst.C.E.

Published by Cassell & Co., Ltd., London. 1908.

Contents: Bending Moments and Shearing Forces.—The Equilibrium Polygon.—Braced Girders, Parallel Type, Curved Type and Roofs.—Cross Sectional Area of the Members of a Structure.—Stresses on Planes Through a Point in a Member.—Beams and Girders with Solid Webs.—Continuous Girders and Cantilever Bridges.—Deflection of Girders.—Arches.—Suspension Bridges.—Earth Pressures and Retaining Walls.—Foundations and Footings.—Masonry Dams.—Straight and Curved.—Concrete Structures Reinforced with Steel Rods where in Tension.

We are glad to observe that the author devotes a chapter to reinforced concrete in this useful handbook on structural engineering, but we are fain to observe that the subject merited more exhaustive treatment in a book of this kind, which is intended to be thoroughly up-to-date.

Speaking generally, the volume will be found a most useful one in every student's library, and in fact in many an office library, where principal or assistant wishes to refresh his memory in matters of calculation, but we trust that in a future edition problems of calculation in reinforced concrete will have greater space accorded them.

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

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EDITORIAL NOTES.

THE CONSERVATION OF OUR NATURAL RESOURCES, SUCH AS IRON, BY THE USE OF CONCRETE.

MR. ANDREW CARNEGIE is probably best known in this country as a philanthropist interested in education and free libraries, but it should not be forgotten that he is also probably the greatest living authority on questions relating to the production of steel, and that any statement by him relating to the position of steel should carry great weight.

At the recent conference of governors and scientists at the White House, Washington, which was held under the chairmanship of President Roosevelt, there was a discussion on the conservation of the natural resources of the United States, in the course of which Mr. Carnegie, speaking of iron, said :—

> The next great use of iron is in construction, especially of buildings and bridges. Fortunately the use of concrete, simple and reinforced, is already reducing the consumption of structural steel. The materials for cement and concrete abound in every part of the country ; and, while the arts of making and using them are still in their infancy, the products promise to become superior to steel and stone in strength, durability, convenience, and economy and use.

Mr. Carnegie's words were intended for an American audience, and solely on an occasion when thought was given to the preservation of the natural resources of the United States, but how much more important these same words would be if spoken in this country for the purpose of preserving our own limited mineral resources.

For a great steelmaker to announce his conviction that concrete promises to become superior to steel and stone in strength, durability, convenience, and economy, is indeed a matter that should claim the attention of our economists.

THE CONCRETE INSTITUTE.

JUST before the commencement of the holiday season the Council of the Concrete Institute held its first meeting, at which the Earl of Plymouth, C.B., presided. Arrangements were made for the first general meetings to be held in October, November, and December, for the presentation and discussion of papers. It was also decided that there should be a spring meeting extending over two days, with the view of giving special facilities for provincial members to attend the discussions.

Prior to this Council meeting there was a luncheon at the Ritz Hotel, with Mr. Edwin O. Sachs, F.R.S.Ed., in the chair, and this served as a " send-off " to the Council's operations. It was pleasing to observe that it fell to the lot of the President of the Royal Institute of British Architects—a body which has done a considerable amount of work in the interests of reinforced concrete—to propose success to the Concrete Institute. This toast was replied to by Sir Henry Tanner, I.S.O., Vice-President, who emphasised the necessity of architects and engineers going more thoroughly into the question of preparing their own designs for reinforced concrete work than they have done hitherto.

We give below a summary of Mr. Sachs' words in proposing the health of the President of the Concrete Institute, and Lord Plymouth's reply in which he raised the very important point that architects must give more attention to the architectural rendering of reinforced concrete buildings in such a manner that practical construction and æsthetic beauty go hand-in-hand.

It is pleasing to observe that the membership of the Concrete Institute already exceeds 250. Sir Douglas Fox, the eminent engineer, has accepted a seat as Vice-President, and the architectural interest has been strengthened by Professor Lethaby's presence on the Council. We would mention that the offices of the Institute are at No. 1 Waterloo Place, London, S.W.

MR. EDWIN O. SACHS ON THE CONCRETE INSTITUTE.

MR. SACHS, after the loyal toast had been honoured, proposed the President, and said :—

This small gathering of the members of the Council of the Concrete Institute is intended as a "send-off" to the Concrete Institute, and to do honour to the Institute's President.

Small as the party is, it however already represents a membership of over two hundred, and includes a few friends who, whilst not yet members of the Concrete Institute, are in sympathy with its objects. Notable among these well wishers is Mr. Ernest George, President of the R.I.B.A., who presides over a body which has done much for reinforced concrete by forming a most useful committee to investigate that subject at a time when the engineering institutions, who might have perhaps more naturally been expected to have done the pioneer work necessary, were giving that subject a cold shoulder.

The Concrete Institute is, in short, intended to do what the Iron and Steel Institute has done for iron and steel, but above all to inquire into the utility of the material, determine its limitations, standardise the methods of calculation, and to regulate and codify the practice.

This type of work can be best carried out by an institute which combines the different, often divergent, interests concerned, and as with iron and steel, so with concrete, an effort has been made to obtain co-operation between the consulting engineer, the architect, the public official, the chemist, the manufacturer or purveyor of the component parts of concrete, the specialist designer, and the contractor. This co-operation in matters relating to concrete has become all important since the introduction of reinforced concrete, a material which has considerable technical and economic advantages, but in respect to which numerous complex problems require immediate solution.

It is to be hoped that all interests concerned will find the work of the Institute not only useful but equitable, and that those concerned, who at times have exaggerated and even discordant views as to their position and rights, will remember that success depends largely on equitable compromise, and that the individual interest is generally best advanced when the community as a whole is making progress.

It has not been easy to combine the various scientific, technical, and industrial interests represented by the Concrete Institute, but having combined them, I expect the *laissez faire* relating to concrete and reinforced concrete which has been so harmful will once and for al! be a thing of the past.

For its future, for its meetings, discussions, and research work, the Concrete Institute has one factor for which other institutions will envy us, and for which we are indeed to be congratulated. We have in the person of the Earl of Plymouth a President whose noted tact, resourcefulness, experience, and special knowledge of construction have endeared him to the members of all the great technical professions. A word of advice from the President, or a hint, will, I know, at all times carry great weight with the members of the Institute, for known at the time as Lord Windsor, he presided over H.M. Office of Works as First Commissioner with such eminent success—and that during a somewhat difficult time—that he can always be relied upon to indicate the right road in an emergency or in a difficult situation.

We all wish Lord Plymouth the best of health to carry on his multifarious voluntary duties, and we trust that as the Institute grows in strength and utility he will be proud of it.

THE EARL OF PLYMOUTH ON THE ARCHITECTURAL RENDERING OF REINFORCED CONCRETE.

THE Earl of Plymouth, replying, said :—

I know you will only expect me, in a word or two, to thank you for the very great kindness you have done me to-day. I wish to say that I most heartily recognise the honour that you have done me in asking me to be the honorary head of this Institute—one which is just formed and quite young, but which surely must have a very great future before it. To be singled out, to be asked to be the first President is a compliment which I value very highly indeed.

I happened to say at Cardiff last week that, in my opinion, good sanitation in the architecture of our buildings and beauty ought to go hand-in-hand, and I wish with very great diffidence to talk of architecture and beauty in the presence of the President of the Royal Institute of Architects (Mr. Ernest George); but I think he will allow me to say without contradiction that *all* practical construction in architecture and æsthetic beauty ought to go hand-in-hand. It is the business of those who have the best practical ideas of construction in their mind to work this out. It is for those who have the beauty of our English buildings foremost in their minds to see how these new practical methods can be turned to the best account, and not clash with our ideas of æsthetic beauty. I am always confident that this is so much the case that one ought never to turn away for a moment from any new idea that is thoroughly practical on the ground that it is not so beautiful as something which has gone before. We have got to get out of any new material the best we can, and so fashion and form it that it will be an element of beauty in our architecture and in our lives.

I only wish to thank you again for the great compliment that you have done me, and to assure you that I look with very great confidence to the valuable and important work which this Institute will carry out.

SIR HENRY TANNER ON THE PRESENT POSITION OF REINFORCED CONCRETE IN GREAT BRITAIN.

IMPORTANT pronouncements on matters relating to technical questions are often met with on the least expected occasions, and such an instance was recently met with at the Cardiff meeting of the Royal Sanitary Institute, when Sir Henry Tanner, I.S.O., as Chairman of the Engineering and Architectural section, dwelt in his address on matters relating to reinforced concrete, and summarised the situation in such a manner that his words will in later days, no doubt, be often referred to as indicating the position of the subject at the present period.

We give Sir Henry Tanner's address as far as it deals with reinforced concrete, and we hold that his views on the position call for the closest attention of those concerned.

Sir Henry Tanner said :—

Generally.

The architectural and engineering professions were more or less conservative, and changes in building construction and engineering practice were gradual and slow; but there were occasions when some marked departure from the usual methods took place with apparent speed. This was generally only after long incubation, and there was something more or less out of the ordinary that had led to it. The introduction of iron joists had a considerable influence on building construction, almost entirely throwing out of use cast-iron or wooden beams; and the introduction of steel further emphasised this change, and for some time past skeleton steel structures had been multiplying. The general desire nowadays was, in regard to the majority of buildings for other than domestic purposes, to provide structures which, while economy had to be duly considered, are the best that can be devised to resist fire; and for this object wood had to be abandoned so far as possible, and all steel had to be covered with some material which was a bad conductor of heat. Portland cement concrete was being generally used for the purpose. This obviously adds to the cost of such structures. The consequence had been that reinforced concrete, which for the last ten years had been occupying the attention of many people, had almost suddenly burst upon the professions in this country, and had provoked an unusual amount of interest. They were much behind other nations in this respect. The question of economy and strength, together with lightness, in the first place forced railway and dock companies to take this method of construction into serious consideration. Owing to bad and unequal foundations upon which, in the case of docks, warehouses, and other similar structures had to be constructed, lightness and homogenity became important considerations. These qualities had considerable influence on cost, which was small in comparison with the usual brick buildings, while concrete piles, which were practically indestructible, took the place of those of wood. The structures thus erected, such as the warehouses on the quays of the Manchester Ship Canal and the goods warehouse at Newcastle for the North Eastern Railway Company, forced themselves upon the notice of architects, and these came to consider why, if such buildings could be erected for railway and dock purposes, the system should not be utilised for ordinary building objects, such as factories and large structures. The various building regulations had stood in the way of the general use of reinforced concrete because, as in steel frame structures, the outer walls were required to be of the same thickness and strength as if they were intended to carry the superstructure, although there were a few local bodies which had permitted elasticity in this respect. At all events, these regulations in the main only permitted the construction of floors and their supports to do the work required. The obstructions thus raised, and the fact that the whole business was practically in the hands of specialists and patentees, had hindered the more general adoption of this form of construction. It was, however, to be hoped that the rules comprised in the Report, which had been prepared by the committee appointed by the Royal Institute of British Architects, might enable local authorities to establish standards, and thus afford freer facilities for users, and that the members of the profession would find it as necessary and as easy to make calculations as they had done in the case of steel.

Loan Periods.

Municipalities had largely availed themselves of this method of construction, and no doubt would more extensively do so were loans obtainable for the same terms as for the ordinary methods of construction. For instance, sewers could, he believed, be constructed at about half the cost of those in brick, but as loans could only be procured for half the usual term, which implied some doubt as to the life of such constructions, the preference was given to old forms by bodies who had not sufficient courage to arrive at an independent judgment, consequently double the money was expended that was necessary; and even if reinforced concrete was adopted, the annual payments are the same in amount, although, of course, there was only half the number.

Advantages.

The advantages of reinforced concrete were numerous, although at present there were comparatively few builders or contractors who laid themselves out to execute such works, but the numbers were increasing and would do so more freely so soon as the system of licences came to an end, while in course of time, he thought, supervision would become more easy as general acquaintance with the construction extended. Reinforced concrete construction was the best fire-resisting system at which they had yet arrived assuming that the steel was properly covered, severe fires showing that it suffered little damage, which, however, could easily be made good, and confined fires within the enclosing area. There resulted a great saving of space owing to the thinness of the external walls, retaining walls, etc., and it was astonishing what pressures these latter could resist. There was no space for vermin, the solidity of the structures being complete, unless such spaces were required for other purposes. In engineering works the economies should be greater than in ordinary building, retaining walls and bridge work showing remarkable lightness and strength. The objection to the material lay in the necessity for foresight, and the early settlement of such items as in ordinary construction generally lead to a large expense in "cutting away," as for lifts, electric lighting appliances, heating apparatus, and similar services.

Practice.

The cost of such operations in reinforced concrete demanded early consideration and settlement on the part of those responsible. He regarded this as a good point as tending to bring these gentlemen up to the scratch, and induce them to make up their minds at an early date instead of postponing everything of the kind till the last moment because "it is so easy to cut holes when and where they are wanted," frequently at those places which had no superfluity of strength. He anticipated that some difficulty might arise in plastering and other internal and external finishings, owing to the non-porosity of the material, and therefore the want of adhesion consequent thereon. However, he had no doubt that this difficulty would be surmounted, and that externally, at least, it would be found possible by the use of suitable moulds to leave the surfaces from those moulds. This he was partially doing already, and in regard to treatment externally there was abundant room for the invention of designers. He found that a 7-in. or 8-in. wall against earth could be made impervious to moisture, here must therefore be a reduction of air passing through as compared with ordinary walls, which should be considered in connection with ventilation problems.

The simplicity of the construction altered the proportion of the trades employed, carpenters taking the place of bricklayers, while labourers could no longer be employed to construct centring as was now the case, but their numbers were largely increased. Consequently, during the construction of the carcase carpenters and labourers were employed in something like the proportion of two to five, bricklayers being seldom needed. The material consisting of round rods, cement, sand, and aggregate there was little trouble in obtaining them, and the delays attending built-up girders and other forms of construction were in the main avoided.

Doubts had been raised as to the stability of this form of construction, but he thought that these need not cause any anxiety to those who used it. It had been repeatedly shown that the steel did not oxydise when covered with concrete such as was used for the purpose, and that accidents, none of which had occurred in this country, had all been traced to causes which should not have existed. The explanation of that at Milan in April last had not, so far as he knew, reached this country, but the photographs he had seen would imply bad or imperfectly-set concrete. Of course, if the work was not properly designed and carried out accidents must occur, as in any ordinary form of construction.

COKE BREEZE AND REINFORCED CONCRETE.

In the House of Commons, the President of the Local Government Board was recently asked if he was aware that the use of coal residues in reinforced concrete has been "forbidden" throughout Germany, and in reply Mr. John Burns indicated that he had no official information on the subject, but he would make inquiries.

Pending Mr. Burns's official reply we would present some facts by way of answer:—

Firstly, the use of coal residues has *not* been forbidden throughout Germany; secondly, the only thing that has so far been done in the matter is that the Ministry of Public Works of Prussia has advised the administrative chiefs of the Prussian provinces (*i.e.*, counties) not to allow the use of what is locally known as Kohlenschlacke—*i.e.*, a coal residue which contains a considerable amount of sulphur, and has the faults common to what is known as *pan* breeze in this country. According to their respective views, no doubt the local authorities of Prussia will limit or bar the use of the unsatisfactory local products, but what bearing any such restriction would have on British building practice we fail to see.

The constant reference to experience with foreign building material, both natural and artificial, is becoming a veritable plague, for the quotation of what may be termed as "half-truths" are most misleading. Building materials of different countries vary in many essentials. The variation in coal residues is a case to point. There is very little risk in using a clean coke breeze as we know it in Great Britain. The only risk is that *pan* breeze or other extraneous matter may be delivered with it, and on this point both contractors and clerks of works might do well to take more care than heretofore. On the other hand, the German product, known as Kohlenschlacke, is certainly an unsatisfactory one, and we can well understand the German authorities' attitude regarding it.

Builders and specialist contractors in our islands, who take due care in the selection of their coke breeze, experience little or no trouble with it. But the same care should be taken in the delivery of coke breeze as of any other building material, and a *sine qua non*, as far as British practice is concerned, is that it should be a clean product of British origin—*i.e.*, from British coal and British gas retorts.

THE LONDON BUILDING ACT.

WE are glad to see that there will at last be some movement on the part of the London County Council to obtain a consolidation and general amendment of the existing Building Acts which in many respects are antiquated.

During the last few years the matter has come forward on several occasions, but a certain apathy has prevented anything very practical resulting up to the present. We trust the proposed amendments will deal fully with the question of steel frame buildings, and with the use of reinforced concrete in structures erected in the metropolis.

Reinforced concrete was for all practical purposes non-existent in Great Britain in 1894, when the Building Act was last thoroughly overhauled, and it is high time, now that this form of construction which has become popular, and is being used with great advantage by our Government departments and other great public bodies, that the London building owner should also be able to make full use of the material.

We take this opportunity of indicating that we hold that much opposition, time, trouble, and expense would be overcome by the London County Council if it promptly obtained the views of the various technical societies concerned as to their proposed Bill prior to the final draft being deposited with Parliament in November next for the session of 1909. Bodies such as the Royal Institute of British Architects, the Institution of Civil Engineers, Surveyors' Institution, British Fire Prevention Committee, and the newly-formed Concrete Institute, should be requested to put in their observations at the earliest possible moment, so that much of the usual unsatisfactory discussion in the House of Commons' Committee may be avoided.

THE INTERNATIONAL COMMISSION ON REINFORCED CONCRETE.

It is with much pleasure that we announce that Professor Schüle, of Zurich, has agreed to act as Chairman of the International Commission on Reinforced Concrete. This office was originally occupied by M. Considère, who formerly held an important appointment in the French Public Works Department, but who recently retired from the chair on going into private business.

Professor Schüle has called a meeting for October to be held in Switzerland, and there will be a further meeting next summer at Copenhagen.

It is to be hoped the Commission will soon get to work in order to assemble and summarise the world's experience of reinforced concrete, for some such summary is urgently required.

REINFORCED CONCRETE STANDARDS AND TELEGRAPH POSTS.

We would like to congratulate the Cubitt Concrete Construction Co. upon the progressive spirit which has led them to lay down machinery for making reinforced concrete standards and telegraph poles. There can be little doubt that the application of reinforced concrete to this particular purpose is a matter of the utmost economical importance, both for the telegraph and telephone service of the country, railway signalling, and electric power transmission.

The expense in renewals and maintenance for telegraph and railway signalling work in particular has become a very serious item for the respective administrations, and the possibility of obtaining a material in long lengths that will not be affected in the same way as timber or metal must be a matter of general interest to a large class of taxpayers and railway shareholders respectively.

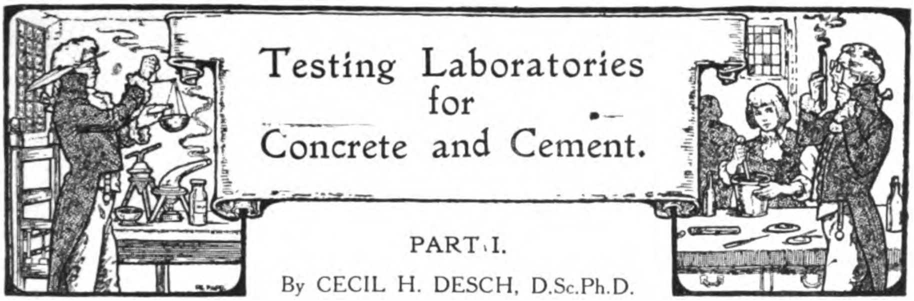
We dealt with the subject at some length last year when describing a Swiss plant where telegraph poles were being produced, and in the current issue the Cubitt Co.'s machinery is referred to under the heading of "New Uses."

CONCRETE DOCKS AND NATIONAL SAFETY.

We have in a previous issue referred to the necessity for dock construction being proceeded with in such a manner as to keep up with, and if possible in advance of, the extraordinary development of the present day in shipbuilding, both naval and mercantile.

We thus observe with pleasure that the daily Press is at last taking up the subject, and a leading article of last month, entitled "Little Docks and Big Ships," was very much to the point.

The advance made in concrete and reinforced concrete should materially assist Harbour Boards, Dock authorities, and the Admiralty to obtain the necessary dock accommodation in an economical manner, and it is to be hoped that full use will be made of modern methods of applying this material.



Testing Laboratories for Concrete and Cement.

PART I.

By CECIL H. DESCH, D.Sc.Ph.D.

The absence of an official laboratory devoted to investigations with concrete and cement may be said to account in no small degree for the dearth of reliable data as to reinforced concrete as designed and executed in this country.

Some testing station enjoying official support, or if conducted as a private enterprise enjoying the reputation of absolute reliability, would be very much in place at the moment, and it might be a matter worthy of the attention of the Concrete Institute to consider the possibility, and ways and means of obtaining for the British Empire some laboratory of this description.—ED.

THE present time is witnessing a revolution in methods of construction, both of buildings and of engineering works. The rapidly increasing use of reinforced concrete, as a substitute for iron and steel on the one hand and for brickwork and masonry on the other, necessitates the adoption of very different methods from those which have served hitherto. And, as necessarily happens on the introduction of a new material with properties peculiar to itself, new problems present themselves on every side to the architect, the engineer, and the contractor. The conditions of stability are not the same as in the older forms of construction, the distribution of stresses in the structure is quite different, the behaviour of the material under the influence of weather, of contact with sea-water, of exposure to fire, is not to be foreseen from experience with other materials. In the long run problems of this kind are solved by the process of trial and failure on a large scale, and the experience is often dearly bought. This fact operates to the disadvantage of a new method in two ways. On the one hand the occasional failures which are bound to occur when the exact conditions of stability are unknown tend to shake public confidence, on the other, cautious architects and engineers, unwilling to run the risk of an accident, employ an unnecessarily massive construction in order to ensure a sufficient margin of safety, hence increasing the cost, and so doing away with the advantage of cheapness which the material would otherwise possess. For the same reason building authorities hesitate to relax the stringency of their regulations in the absence of exact means of dimensioning the structures, one result being that architects are compelled to erect walls of altogether excessive thickness, thus adding greatly both to the cost and to the weight of the building.

The acquisition of experience by trial on a large scale being so costly and unsatisfactory, it is natural to enquire how far a knowledge of the properties of a new material can be arrived at by investigations in the laboratory, where experiments may be made on a small scale to determine the influence of mechanical stress and of physical and chemical changes on the material itself and on structures composed of it. The experience, especially of foreign nations, goes to show that this is the proper course to pursue. Wherever laboratories have been established for this purpose the benefit to the professions and industries concerned has been great and lasting. As regards reinforced concrete as used abroad, thanks to the investigations of scientific workers in many countries, an enormous mass of information is now available, and the mechanical principles underlying the construction of beams, columns, floors, arches, domes, etc., are now fairly well understood, although even abroad a great field for further research still remains open. As to the investigations with reinforced concrete in this country, however, they have been quite exceptional, and with a few exceptions almost of a haphazard character, so that a very great deal remains to be done as far as British practice is concerned.

The mechanical conditions of stability are by no means the only questions which fall to be investigated in such a laboratory. The quality of the concrete depends on the quality of the materials composing it (cement, sand, and aggregate), on their proportions, and on the conditions of mixing. The whole subject of cement bristles with problems for the chemist and the engineer. It is very remarkable how the necessity of using cement of high quality in reinforced concrete work has led manufacturers to improve their methods, so that the quality of the Portland cement of the leading makers has steadily risen in recent years. Standard specifications need to be revised from time to time, and the changes made are invariably in the direction of increased stringency. Even those engineers and contractors who are not satisfied with the standards, and adopt a more severe specification for their own use, find the manufacturers able to comply with their requirements. But even yet the properties of cement are far from being thoroughly understood. Results are occasionally obtained which are inexplicable, and of the changes which take place during storage very little is known.

Comparatively little attention has been given to the subject of aggregates, but the experiments of the British Fire Prevention Committee have shown the importance of this factor in determining the fire-resisting properties of concrete, and the investigations of the Concrete Aggregates Commission, now sitting, have disclosed a number of points requiring experimental study.

In the present series of articles it is proposed to describe the more noteworthy laboratories devoted to cement and concrete investigations in this and other countries, the present introductory article dealing with the general nature of the equipment required in such a laboratory. In the great Continental testing institutions, such as those at Gross-Lichterfelde, at Berlin, and at Zürich, the testing of metals, wood, stone, etc., and even paper and lubricating oil, is undertaken as well as that of cement and concrete, and some of the machinery serves more than one purpose, but this does not materially alter the position, so far as the greater part of the equipment is concerned.

Experiments of this kind need to be continued over a long time, on account of the slowness of the changes which take place in the mass after setting, and this necessarily demands considerable storage space, where blocks and beams can be kept at a temperature as uniform as possible over many months or even years. Tanks are also required in which blocks and briquettes may be kept immersed in water for long periods. Samples of cement need to be stored in a dry place in order to study the effect of ageing, as to which much obscurity still prevails. The mixing of mortars and concretes is best done by hand, for although small laboratory mixers are made and used, they present no advantages over hand mixing when carefully carried out. On the other hand, the ramming of tensile briquettes and compression cubes is best done by an automatic machine, which delivers a fixed number of blows of equal force and then disconnects itself from the driving gear. This is of great assistance in ensuring uniformity of results. The mechanical sieves for testing the fineness of cement are best placed in this room, where the dust to which they unavoidably give rise will cause no inconvenience.

The machines used for mechanical tests range from the little table machine for tensile tests on briquettes, in which the load is applied by the flow of shot into a scale-pan, up to the huge machine for testing reinforced concrete beams 15 ft. in length, the load being applied hydraulically through seven or eight rams. The larger compression machines, capable of crushing 6 in. or 8 in. concrete cubes, are always hydraulic, the pumps and rams preferably working in oil. It is a convenience to be able to apply the load mechanically, and suitable gauges for registering the load at the moment of fracture must be provided. It is generally possible to adapt the same machines to making transverse tests with central loading on small beams, plain or reinforced, and on concrete pipes. When it is desired to test full-sized columns a vertical machine of the same type, but of greater height, is employed; crushing tests on columns in a horizontal machine are not satisfactory.

The setting time is still most conveniently determined by means of the Vicat needle, which gives thoroughly consistent results in skilled hands, and has not been superseded by automatic recording needles or by Prof. Gary's thermal method, ingenious as the latter undoubtedly is. The needles, the hot chamber for the Le Chatelier expansion test, and the table machine for testing briquettes may conveniently stand near one another on a side bench of the main testing room. Opinions differ as to the best means of testing cement for expansion, for whilst some merely examine thin pats for warping or cracks, others use elaborate patterns of micrometers. The simple Le Chatelier split cylinder is perhaps the most generally employed.

A test which is not made in all laboratories, but which is of great importance to engineers and contractors, especially in connection with reservoirs or water towers, is that for permeability, water-pressure being applied to blocks or discs of mortar or concrete, and the rate of leakage observed. The apparatus is comparatively simple, and easily erected. Sufficient space should always be provided for erecting temporary apparatus for a special purpose, when it is desired to test the corrosive action of steam or chemical fumes, the effect of frost, or any other of the many questions which present themselves in connection with concrete building or engineering works. Tests for fire-resisting properties need to be made on a rather large scale, and a separate building is necessary for their execution.

The chemical laboratory should always be distinct from that used for physical and mechanical tests, as only in this way can proper cleanliness be preserved. A chemical laboratory for cement need not be large, but must be well equipped, as the operations of silicate analysis are delicate and require many precautions. Of course, the analysis of cement is only a part of the chemical work connected with the industry, as many other matters, such as the liability of certain aggregate materials to oxidation and the changes brought about by contact with sea, mine, or peaty waters, fall to be investigated in this way.

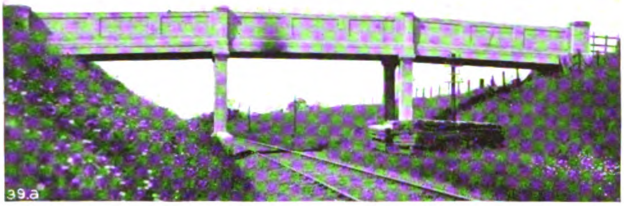
Provision must be made for the proper recording of all experimental results. Where the number of samples is large and tests are made at intervals over long periods this is a somewhat complicated matter, and requires a thorough system of card indexing. The room in which these records are kept may also contain the delicate balance for chemical work and the microscopic equipment. In view of the progress that has been made in recent years the microscope must be considered an indispensable auxiliary in the scientific investigation of cement, and provision should be made for the photography of the micro-structures observed. The photographic method is also successfully employed in recording the mode of cracking of beams and other structures under load.

Such is, in broad outline, the general character of the equipment of a laboratory devoted to cement and concrete, gathered from a comparison of the principal existing laboratories at home and abroad. In succeeding articles the appliances in use in several of the most important of these will be described in detail. Some of the establishments to be considered are State institutions, as at Berlin and St. Louis, others, as at Stuttgart, are departments of technical colleges, some, as at Zürich, combine the two characters. In this country official patronage has played a less conspicuous part than private enterprise, and the most complete laboratories are those erected by the leading cement manufacturers and by contractors who are seeking to improve their methods of construction. When all is said, it must be admitted that this country lags behind other nations, especially Germany and Switzerland, in its provision for the investigation of the problems connected with concrete, and it is to be hoped that the newly-formed Concrete Institute, so fully representative of all the interests concerned, may be able to do something to remove this reproach. Although much of the knowledge acquired as the result of experiments abroad may be applied to the conditions existing here, this by no means dispenses with the necessity of independent investigations, apart from routine controlling tests. Differences of material and differences in climatic conditions make it indispensable for each country to make a systematic study of its systems of construction, and the results of such study react beneficially on both science and industry, adding at once to scientific knowledge and to the security and material well-being of the community.

(To be continued.)

REINFORCED CONCRETE ON THE GREAT EASTERN RAILWAY.

PART II.—GENERAL WORKS


39.a

BRIDGE ON THE G.E.R. BETWEEN NORTH ELMHAM AND COUNTY SCHOOL.

By EDWARD A. WILSON, A.M.Inst.C.E.
Assistant Engineer Great Eastern Railway.

In an earlier issue we dealt with reinforced concrete on the Great Western Railway, and in our last issue we published an article from the pen of Mr. Edward A. Wilson, A.M.Inst.C.E., on the subject of Reinforced Concrete on the Great Eastern Railway, which was mainly devoted to bridges on that line.

The article we print below deals with general work in reinforced concrete on the same railway, and it is pleasant to observe the increase in the use of reinforced concrete on such of our railways where economy in construction and maintenance is considered a matter of the first importance.—ED.

IN the previous article no mention was made of some occupation bridges which have been re-constructed in this material. The design in every case was similar, the parapets of the spans, which are independent, acting as girders.

The reinforcement is in the form of a bowstring truss, the booms composed of "useful" 80-lb. bull-headed steel rails, the verticals of 1-in. circular rods, the whole supporting a continuous slab floor 11 ft. wide and 8 in. thick, reinforced transversely with five No. ½ in. circular rods to the foot. The piers are formed of two columns braced at the top, each containing two "useful" rails.

40.a

PARKESTON QUAY EXTENSION.
(View of reinforced concrete bracing.)

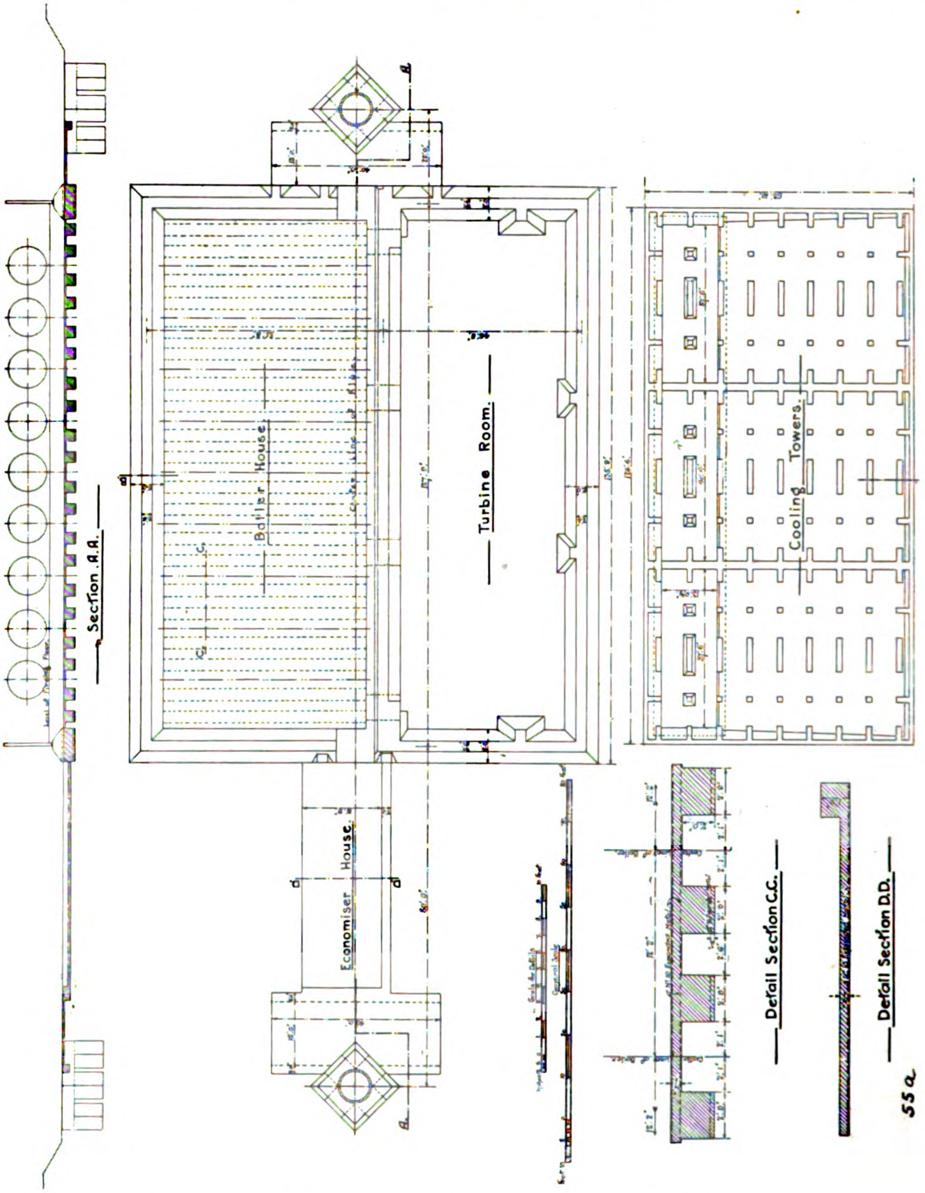
Shortly after the completion of the work a span was loaded with 2 cwt. to the super foot; the deflection on the main girders was inappreciable, and on the flooring amounted to 1/32 in.

Although these bridges at present span only a single line, it was considered advisable, as the cost was not materially affected, to re-construct them for double line in view of future widenings with a clear span of 25 ft. 4 in. above "Platform" level.

Stratford Power Station. — Prior to 1906 practically the only electricity consumed by the Great Eastern Railway was for lighting purposes, but it had been considered desirable to utilise it for power at Stratford in the Locomotive and Permanent Way Shops and the Printing Works, and also to extend the lighting to both Stations and Goods Yards in the suburban area, and for these purposes to construct a central Power

Station in place of the existing one at Norton Folgate, the latter to be used as a transformer station.

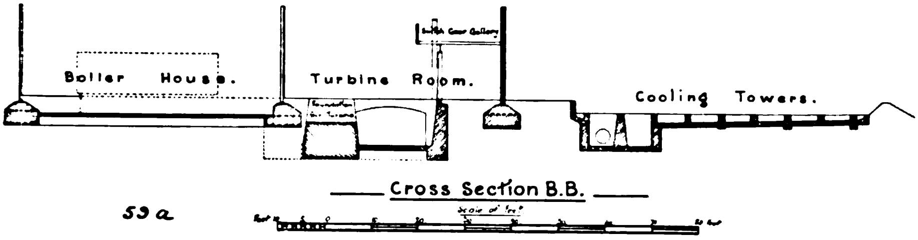
The site settled upon ultimately was at Stratford, where the Company already possessed land of sufficient area for both present and future requirements, and, as it practically adjoined the locomotive works, it was in a particularly convenient position. The ground was originally marsh land on the banks of the river Channelsea, but from time to time it had been tipped upon until the level was raised about 11 ft.



STRATFORD ELECTRIC POWER STATION.
(General plan and details of reinforced concrete foundations.)

The subsoil of water-bearing gravel is 16 ft. below the tipped surface, so that in order to save heavy foundations for the turbines and condensing plant, which it was decided should rest on the gravel, an average depth of 3 ft. was first removed from the whole area, and the remaining buildings, consisting of boiler-house, turbine room, economiser house, chimneys and cooling towers, were floated in the made-up ground. Dealing with the foundations of the main buildings, the weight of these, together with the wind pressure, was calculated, and gave a maximum load of 20 tons at each stanchion. It was then assumed that these loads were equal in effect to an upward pressure of like amount evenly distributed over the whole area; then, by regarding the stanchions as piers, the bending moments were found, and the concrete foundations were designed as continuous girders.

As the spans thus formed were only just over 9 ft., no breaks were made at the points of contraflexure in the top and bottom reinforcements, which were carried through continuously.



53 a

STRATFORD ELECTRIC POWER STATION.
(Details of reinforced concrete foundations.)

The boiler-house contains nine boilers, each 30 ft. long and weighing approximately 60 tons. A pressure of 12 cwt. per super foot was taken as the maximum that this made-up ground could resist with safety.

Two trenches were cut under each boiler site and filled in with concrete, reinforced on the underside to provide for any deflection due to inequalities in the foundation material. The piers so formed support a continuous slab floor 7 in. thick, reinforced top and bottom.

The weight on the condenser pit floor was insufficient to render reinforcing necessary, but it was considered advisable to employ a certain amount in the turbine and motor foundations to resist any vibrational alternating stresses which might occur.

The switch gear gallery was also of continuous slab design carried on joists at 2 ft. 8 in. centres, and was calculated by means of empirical formulæ. In testing to the required load no appreciable deflection occurred.

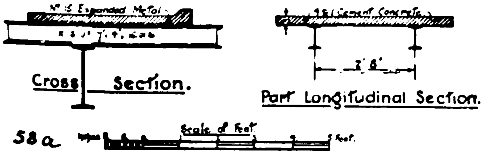
Expanded Metal Co.'s Empirical Formula,

Moment of resistance $= K\ b\ d^2$ in. lb. Where K is a constant found by experiment to be 300, *b* is breadth of slab in inches; *d* is overall depth of slab in inches.

In the present case, taking a breadth of 1 ft., the moment of resistance

$$= 300 \times 12 \times (3)$$
$$= 32,400 \text{ in. lb.}$$

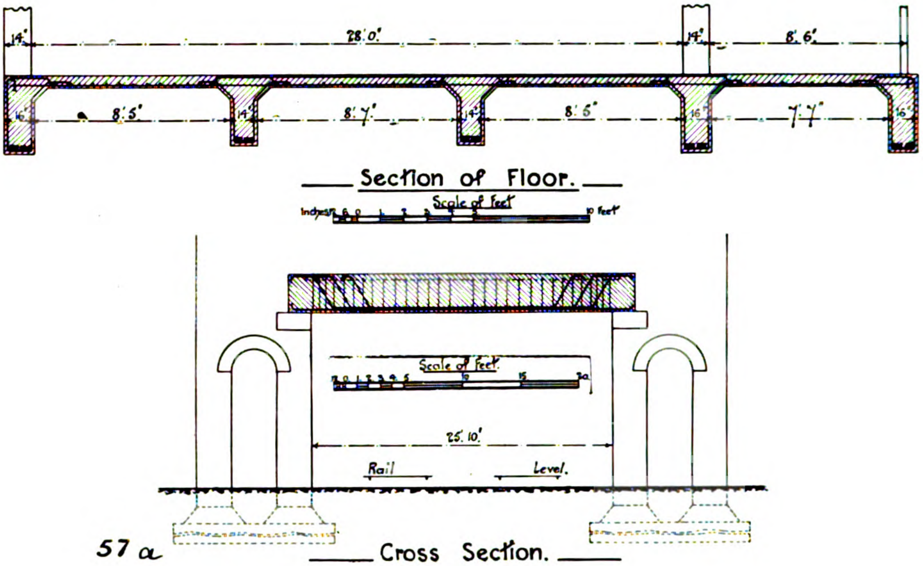
which when equated to the maximum bending moment will be found amply strong.



58 a

STRATFORD ELECTRIC POWER STATION.
(Reinforced slab on switch gear gallery.)

As the whole of the land on which the power station was built is water-logged at times, especially at abnormally high tides, it was necessary that the foundations of the cooling towers should resist external water pressure; they were therefore further reinforced and the tanks made waterproof.



Section of Floor.

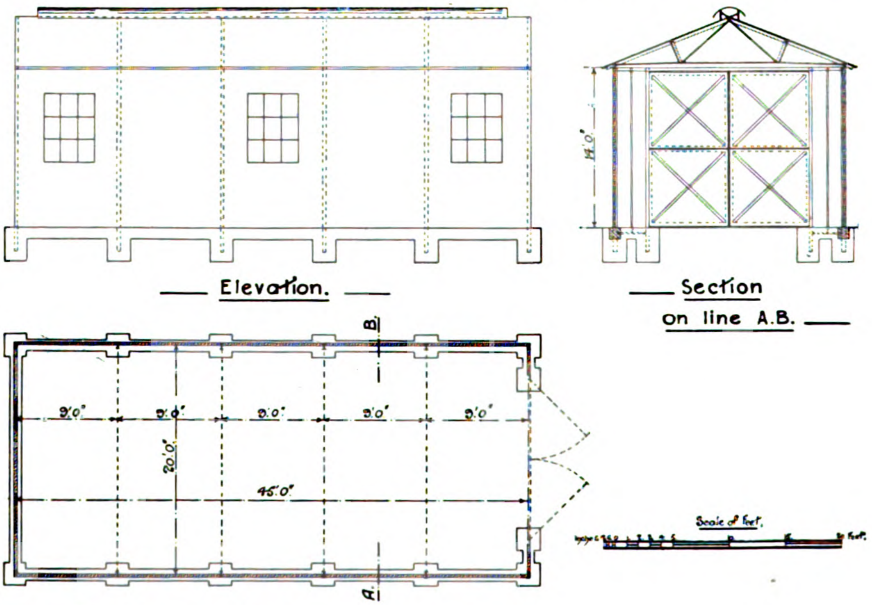
57 a

Cross Section.

ANGEL ROAD STATION.
(Reinforced concrete floor to booking hall and office.)

Throughout the work the reinforcement used was Expanded Metal of varying mesh and gauge, and, in spite of extreme differences in the nature of the ground in the several parts of the building, no settlement has taken place.

As regards both price and suitability the method adopted was found to be the



Elevation.

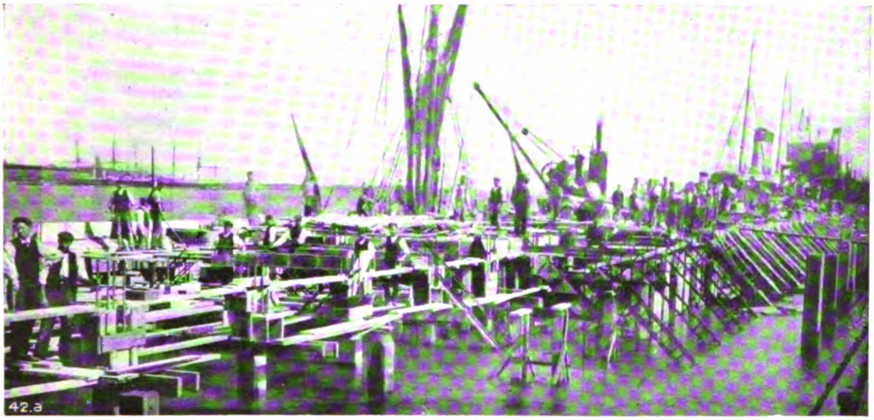
Section on line A.B.

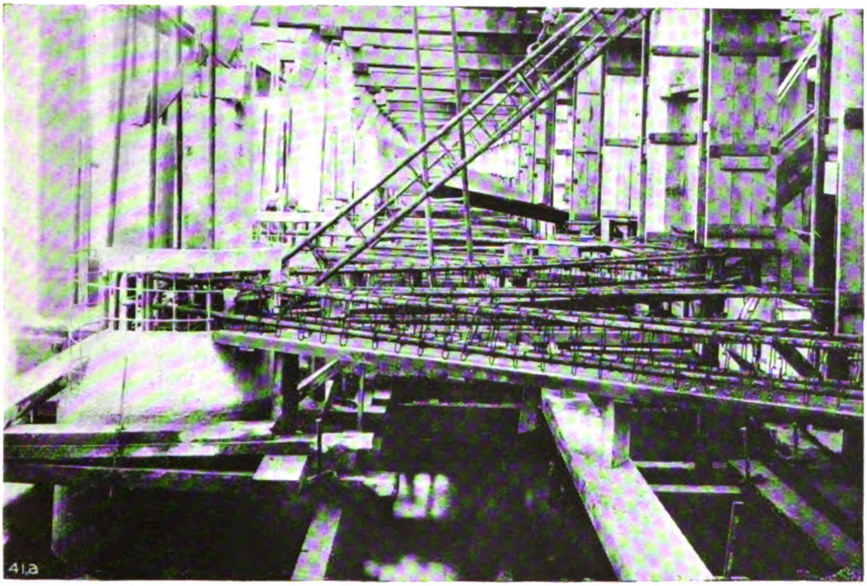
56 a

Plan.

KELVEDON LOW LEVEL STATION, ENGINE SHEDS.

most advantageous; for although the work might have been carried out on timber piles; these would have speedily rotted owing to the fact that they would have been alternately wet and dry, whilst if the concrete foundations had been carried down to the gravel the cost would have been prohibitive.





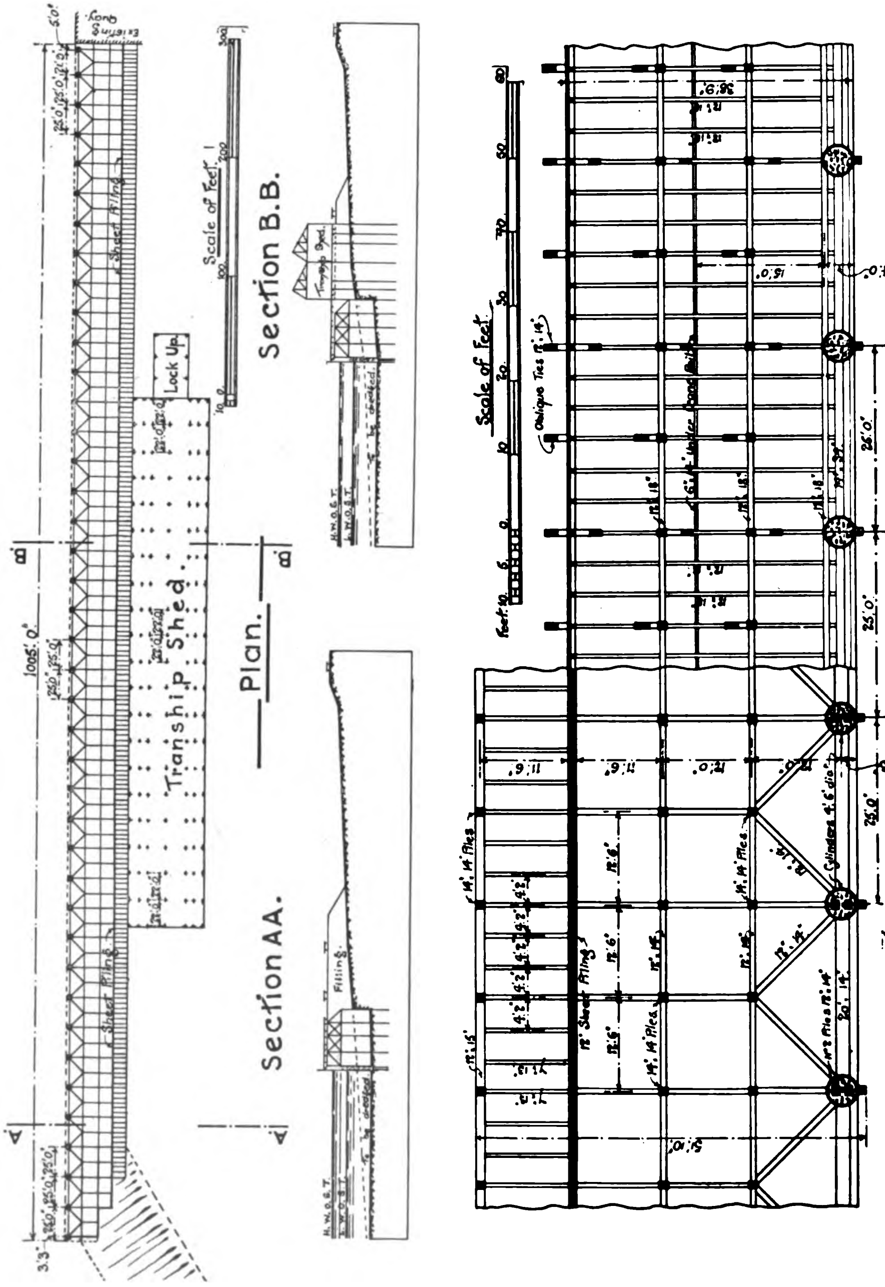
Parkeston Quay Extension (Reinforced concrete work in course of construction).

Angel Road Booking Hall.—In connection with the provision of the overline bridge described in the previous article, it was necessary to demolish the old booking hall and erect a new one at the higher level.

As the bridge is being constructed entirely in reinforced concrete, advantage was taken of this fact to utilise the same material in the booking hall floor, which spans two lines of railway, and would therefore be liable to deterioration from sulphur gases if the usual type involving exposed steel were used.

The design adopted is a girder and slab decking similar to that used in the bridge.

Kelvedon Engine Shed.—At the low level station built here as a terminus of the Kelvedon and Tollesbury Light Railway, it was necessary to construct a shed to house the one "engine in steam" allowed by the Light Railway Order. The formation is a bank about 15 ft. above the previously existing ground-level, and although the shed



52a Section D.D. from below. Section C.C.

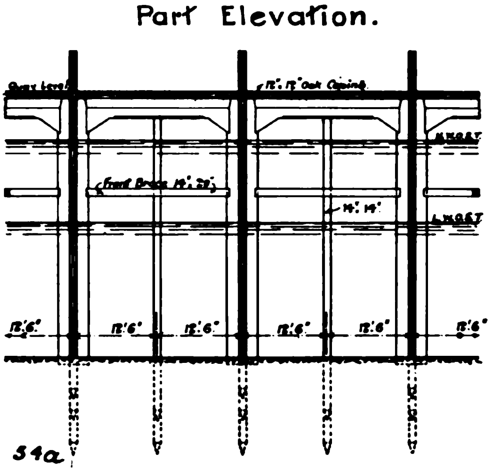
Parkeston Quay Extension (Plan and details of reinforced concrete work).

had to be fire and weather proof, it was most necessary that the design should be very light to avoid heavy foundations.

The structure is of steel and concrete, and whilst it can hardly be described as reinforced concrete, it is allied very closely with that material.

Stanchions of H-section occur at 9 ft. intervals, the intermediate panelling is "dove-tailed" sheet steel 2 in. over flats, the interstices are filled with concrete, having a face of 1 part of Portland cement to 1 of sand, making a total thickness of 3 in.

The corrugations are horizontal, and as the maximum amount of metal is removed as far as possible from the neutral axis of the section, any danger from buckling under wind pressure is prevented.



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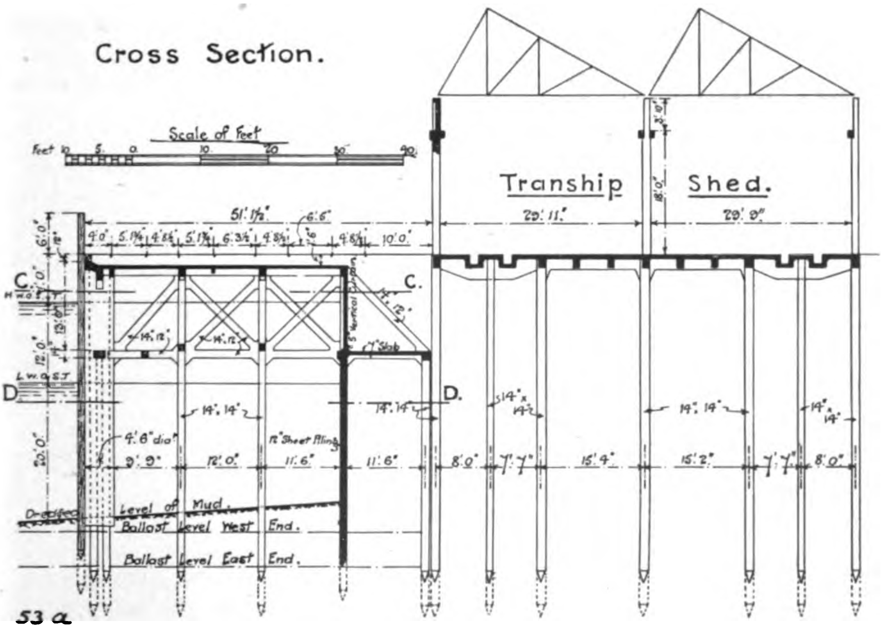
PARKESTON QUAY EXTENSION (Details).

The roof, carried on steel trusses, is of similar design and has wood strips covered with copper inserted at every 5 ft. to prevent cracks arising from thermal stresses.

Parkeston Quay Extension.—As these works were very exhaustively dealt with in Vol. II., No. 3, of this journal, it is unnecessary to dwell at any length on the subject except in so far as the actual carrying out of the work is concerned.

The chief difficulties to contend with as regards design and construction were the large amount of mud overlaying the ballast, in which alone a satisfactory founda-



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PARKESTON QUAY EXTENSION (Details).

tion could be obtained, rendering it impossible to do any shuttering at a low level; and further, that the weather conditions last winter were such that tides were very seldom down to the normal, thus causing great delay in setting the columns and forming that part of the structure situated at or about low water of ordinary tides, added to which on several occasions during gales the unset concrete and the false work were washed away.

The consistency of the mud is such that it gave practically no lateral support to the piles, and it was found that these, when pitched, in the majority of cases went down more than 15 ft., penetrating the remaining depth to the ballast with the weight of the monkey alone. These conditions necessitate great strength in the structure to contend against the lateral force exerted by the filling at the back of the sheet piling.

The tidal trouble was overcome by lengthening the piles to include the columns, and after these had been driven to the required set, ½ in. for the combined ten blows of a two-ton monkey falling 3 ft., the concrete at the level of the lower horizontal bracing was broken away and the reinforcement of this put in position and interlaced with that of the column, the whole joint being then filled up solid with concrete.

A tranship shed, with customs offices and lock-up, is now being constructed, carried on piles, with reinforced concrete floors similarly supported.

The corrugated iron walls are framed in reinforced stanchions and beams, the latter also serving as roads for traversing cranes in the shed and semi-portal cranes on the quay, a row of concrete columns down the centre supporting the valley of a weaver roof and further crane roads.

The two sidings which pass through the shed are carried on longitudinal timbers in reinforced troughs, so that the top surfaces of the rails are level with the paving.

By providing a floor of this description the risk of damage to goods by fire or water is minimised; at the same time the very heavy maintainance inseparable from an earth or timber floor is obviated.

The strength of the foundations provide for a second story to be added to serve as a bonded warehouse should the necessity arise.

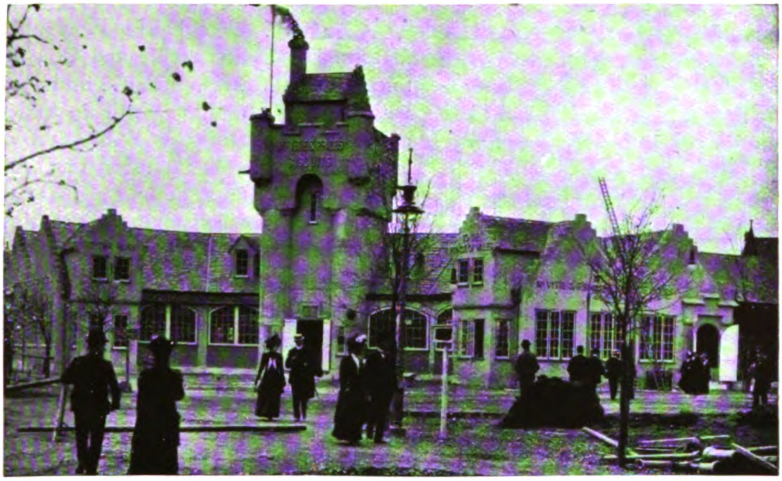


Fig. 1. General View of the Bakery at the Exhibition.

REINFORCED CONCRETE AT THE FRANCO-BRITISH EXHIBITION.

We are presenting some particulars of the reinforced concrete work at the Franco-British Exhibition, but regret that the examples are not more numerous, the cause of this being that the majority of the structures were solely intended as temporary buildings; in fact, most of the Exhibition buildings have only been licensed to serve as temporary structures to the end of the current year.—ED.

To engineers, architects, and others concerned in constructional work the Franco-British Exhibition naturally suggests an interesting and comprehensive show of reinforced concrete worthily representing the numerous British firms by whom that material has been taken up within recent years, and the various French firms who have employed reinforced concrete so extensively on the other side of the Channel.

Unfortunately there is comparatively little to see at Shepherd's Bush in the way of reinforced concrete construction. On the occasion of our first visit the flooring of the Stadium appeared to constitute the only finished example of work such as that of which we were in search, although scaffolding and materials gave preliminary evidence of the reinforced concrete spiral stairway, since completed, opposite the Australian Pavilion in the Grand Avenue of the Colonies.

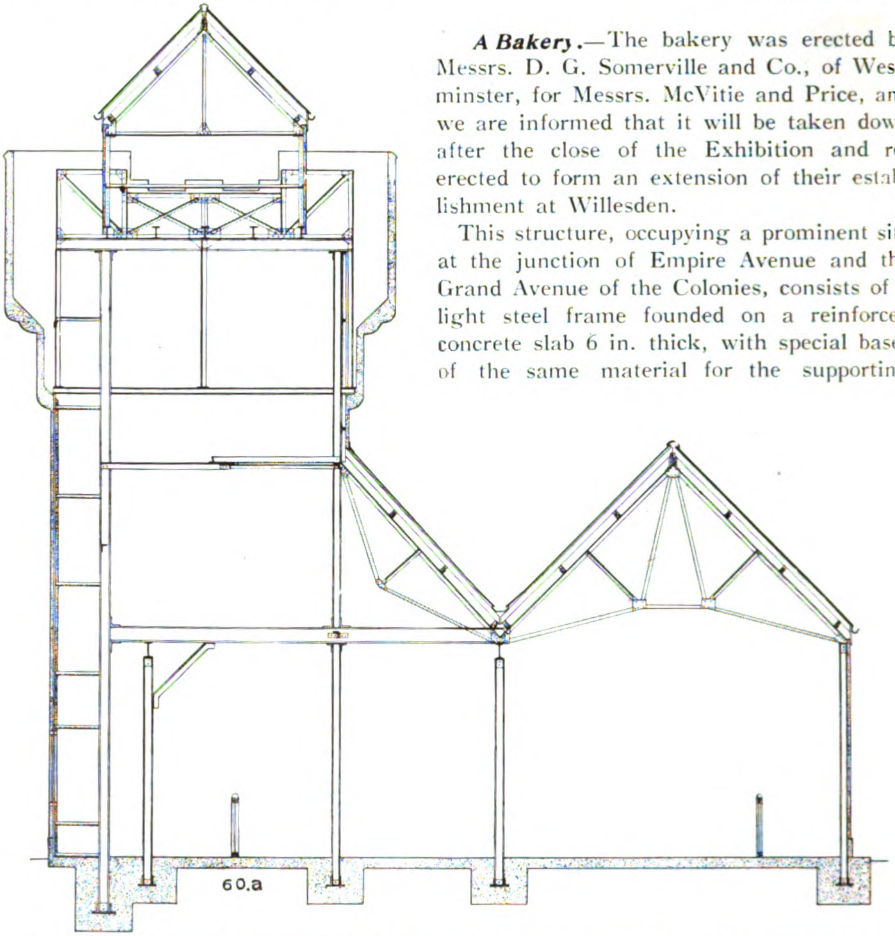
Subsequent investigation brought to light the fact that reinforced concrete was employed in the erection of the model bakery in Empire Avenue, and that some exhibits of similar character were hidden away in the French section of the Machinery Hall. The official catalogue proved of little or no service and the Commercial Bureau was still more useless, notwithstanding the glowing encomiums printed in the Official Guide concerning that department.

In the Paris Exhibition of 1900 many of the buildings and other structures were in themselves magnificent exhibits of reinforced concrete practice, whereas at Shepherd's Bush the pavilions almost without exception are of steel or timber faced with plaster, and in some cases provided with plain concrete floors and partitions.

Apart from the Stadium flooring, described in our issue of May last, the only building embodying reinforced concrete construction is the bakery already mentioned, and of which we now give a photograph in Fig. 1, a plan in Fig. 2, and a section in Fig. 3.

A Bakery.—The bakery was erected by Messrs. D. G. Somerville and Co., of Westminster, for Messrs. McVitie and Price, and we are informed that it will be taken down after the close of the Exhibition and re-erected to form an extension of their establishment at Willesden.

This structure, occupying a prominent site at the junction of Empire Avenue and the Grand Avenue of the Colonies, consists of a light steel frame founded on a reinforced concrete slab 6 in. thick, with special bases of the same material for the supporting columns (see above). The roof trusses are of steel carrying timber purlins and rafters, and covered with French tiles. The wall panels, including those of the tower, are filled in with reinforced concrete slabs 3 in. thick, the outer surfaces being rendered and finished with pebble cast, giving a massive and very effective appearance.



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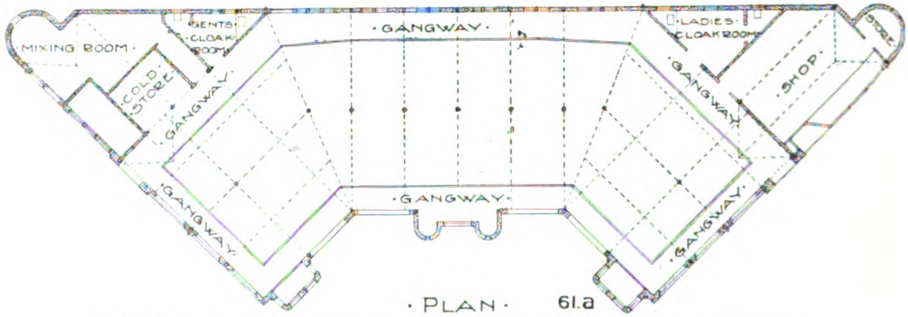


61.a

Figs. 2 and 3. Reinforced Concrete Bakery at the Franco-British Exhibition.
(The Exhibit of Messrs. McVitie & Price.)

The system of foundations here illustrated was adopted for the reason that owing to the instability of the newly-made ground there would have been considerable risk of settlement if ordinary footings were employed, unless these had been carried down to the underlying bed of clay. Both alternatives were considered, and the reinforced concrete method was finally selected, because it offered maximum security at minimum cost.

A Reinforced Concrete Stairway.—A structure at Shepherd's Bush demonstrating in a striking manner the adaptability of reinforced concrete to engineering and building construction is the spiral stairway of 54 steps, erected by the Yorkshire Hennebique Contracting Company, of Leeds, from the designs of Messrs. L. G. Mouchel and Partners, Ltd., of Westminster.

Visitors will find the work to which we refer near the Irish Village at the far end of the grounds, and from the cantilever platform at the summit an excellent view can be obtained of the surrounding parts of the Exhibition.

From the drawing reproduced in *Fig.* 4 it will be seen that the design is of remarkably bold and graceful character. Rising from a relatively small foundation the stairway takes nearly two complete turns without any support above ground level, the spiral coils and the projecting platform being held up solely by the elastic strength of the reinforced concrete construction.

Of course, in actual practice a stairway of this kind would be in monolithic connection at the bottom and top with the floor beams of a building, and so there would be little or nothing tending to compress the work bodily like a spiral spring, as happens in the case of the isolated structure at the Franco-British Exhibition. Instead of being finished by a cantilever platform the stairway would land passengers upon part of the floor above, itself of sufficient rigidity to relieve the spiral from any loads other than those represented by the weight of the materials and the live load of persons ascending and descending.

Moreover, rigid connection at the top would remove or reduce to insignificant proportions another problem for solution in the design of the present independent structure, which to the uninitiated may seem to be in danger of falling laterally under heavy eccentric loading.

All these are points appealing to architects and engineers, and serving to enhance interest in the stairway as actually constructed at the Exhibition.

From the ground to platform level the height is 27 ft., and the overall diameter of the spiral is 16 ft. 4 in., the stairway proper being composed of two curved stringers, 8 in. wide by 2 ft. 4 in. deep, 4 ft. apart, and connected by stair treads with the rise of 6 in., and varying in width from $7\frac{1}{4}$ in. at the inner curve to $15\frac{3}{4}$ in. at the outer curve.

The cantilever platform is bounded by a curb 8 in. wide by 1 ft. 6 in. deep, and finished by a 4 in. slab. Iron railings are fixed along each side of the stairway and around the platform so that visitors may ascend without any sense of insecurity.

Fig. 5 is a plan showing the general arrangement of the steps and platform, and in *Figs.* 6 and 7 are details of the stairs, platform, and stringers.

The foundations extend to the depth of only 3 ft. below ground level, and consist of a rectangular caisson 16 ft. by 10 ft. in plan, formed of longitudinal and transverse beams connected at the top by a continuous slab. Two of the beams beneath the commencement of the spiral stringers measure 18 in. wide by 24 in. deep, all the others being 9 in. wide by 16 in. deep, while the connecting slab is 5 in. thick. The general arrangement of the foundations is illustrated in *Figs.* 8 and 9.

The design of a stairway such as this is a task that could only be attempted with any hope of success by engineers possessing the double qualification of familiarity with the calculation of stresses, and a complete mastery of reinforced concrete construction. In addition to tensile, compressive, and shearing stresses the structure has to resist torsion developed by the deadweight of material and the live loads super-

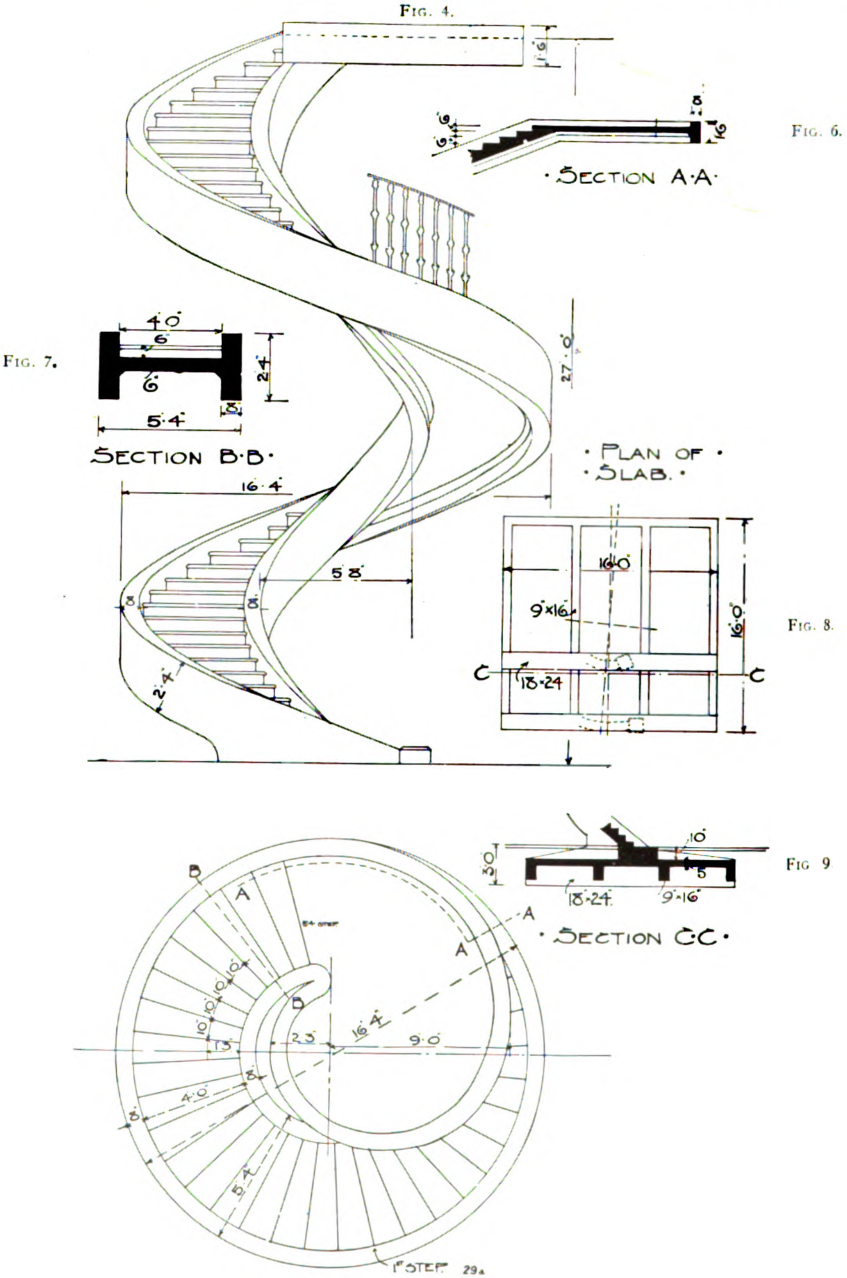


Fig. 4.

Fig. 6.

Fig. 7.

Fig. 8.

Fig 9.

Fig. 5.

The Reinforced Concrete Stairway at the Franco-British Exhibition.

imposed, the tendency of these being to induce a twisting effect. Further, the designers had to take into account the influence of unbalanced loads on different bends of the spiral, a condition evidently increasing the complexity of the general problem in no small measure.

Finally, there remains the important question of the stability of the work. Calculation shows that the centre of gravity of the stairway when uniformly loaded or without any superimposed load passes through a point whose position is an adequate guarantee of stability. To test the effect of eccentric loading calculations were made assuming all the stairs and part of the platform at one side of the centre line to be crowded with people. The result demonstrated the fact that even under conditions so trying, and, of course, scarcely likely to occur in reality, the centre of gravity would pass through a point only a few inches away from that corresponding with the centre of gravity for uniform loading. Therefore, under all possible conditions, the stability of the structure is fully assured.

We should like to add that the reinforcing steel used on this work was supplied by The Whitehead Iron and Steel Co.

Some Exhibits.—Turning to the exhibits in the French section of the Machinery Hall the visitor will find on the stand of M. Edmond Coignet (or " Coionet," according to the Official Catalogue) two samples of beam reinforcement, two models illustrating pile and pipe construction, and photographs of various buildings erected on the Coignet system in Great Britain and abroad.

M. Considère exhibits two pieces of a pile with spiral reinforcement, some small blocks of concrete, and drawings giving particulars of the Viaduct of Avranches, which was fully described in our issue of January, 1907.

M. Hennebique (printed as " Hennesique " in the Official Catalogue) exhibits photographs of bridges, water towers, coal silos, quays, warehouses, and other structures in Great Britain and on the Continent.

The Société Générale de Constructions en Béton Armé (whose trading style is also misspelt by the Exhibition authorities) have presented a very interesting collection of photographs, but these unfortunately do not explain in any way the principles of construction followed, and therefore are of no practical value.

The French Ministry of Public Works include in their exhibit some drawings showing the application of reinforced piles, columns, beams, and slabs in harbour works at Boulogne.

On the whole, while thoroughly appreciating the value of certain exhibits to which attention has been given here, it must be admitted that the Franco-British Exhibition is disappointing in the extreme to those who visit it in the hope of finding a representative display of reinforced concrete construction.

THE NEW SCHOOL OF ANATOMY AT MUNICH

A GENERAL VIEW.

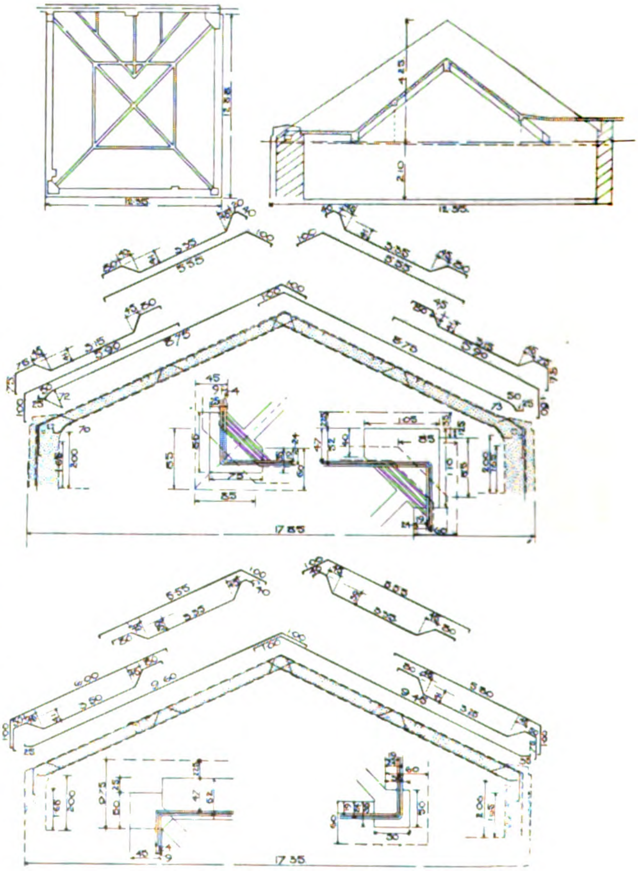
From time to time we think it advisable to publish examples of important buildings erected abroad, in which reinforced concrete has been applied to some considerable extent, and we have selected these buildings not only from the continent but also from the United States.

In this instance we present particulars of a most interesting building in Munich, which is perhaps worth inspection on the spot.

We would point out that it is designed by the architects who designed the Drapery Stores in Munich, a description of which was published in our first issue of March, 1906.—ED.

This very interesting building has been constructed from the designs of Messrs. Heilmann and Littmann, of Munich, the Eisonbeton Company of that city acting as contractors.

In plan this building is considered to have numerous features of importance to the medical profession, and to thoroughly fulfil modern requirements. But entirely apart from any question relating to the special utility of the building for the purpose for which it has been constructed, it has on the one hand features of interest in its construction, and on the other features of interest in its architectural rendering.



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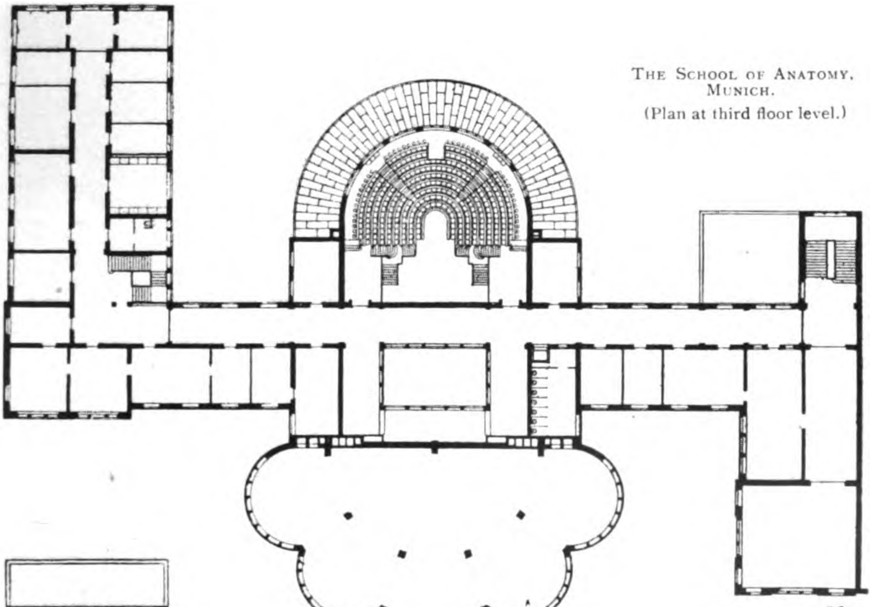
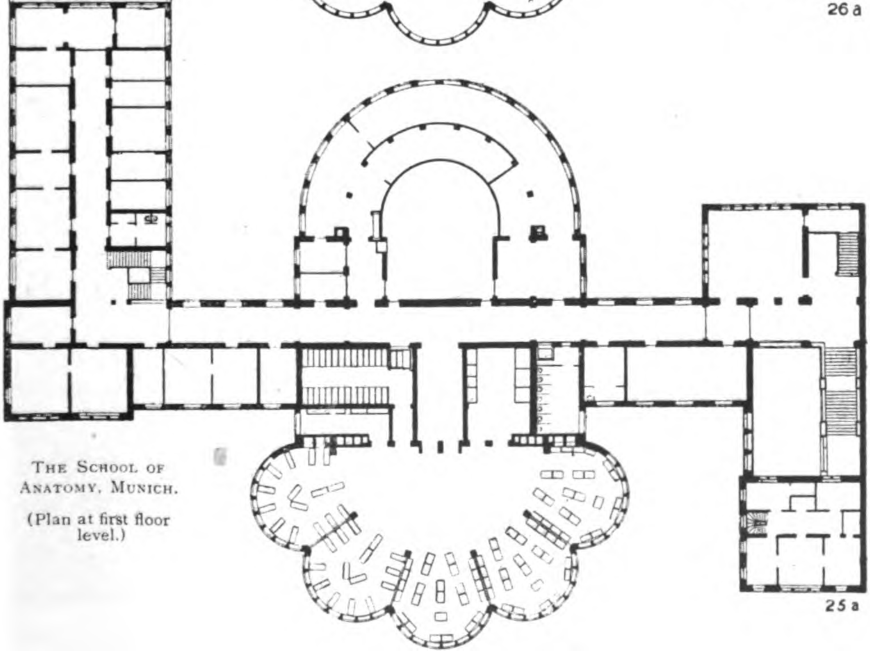
THE SCHOOL OF ANATOMY, MUNICH
(Details of roofs.)

Regarding its construction it stands as a somewhat unique example of the application of reinforced concrete in peculiar circumstances, whilst architecturally it embodies various theories as to the architectural rendering of reinforced concrete with due regard to æsthetic requirements, and without incurring expense for special ornamentation.



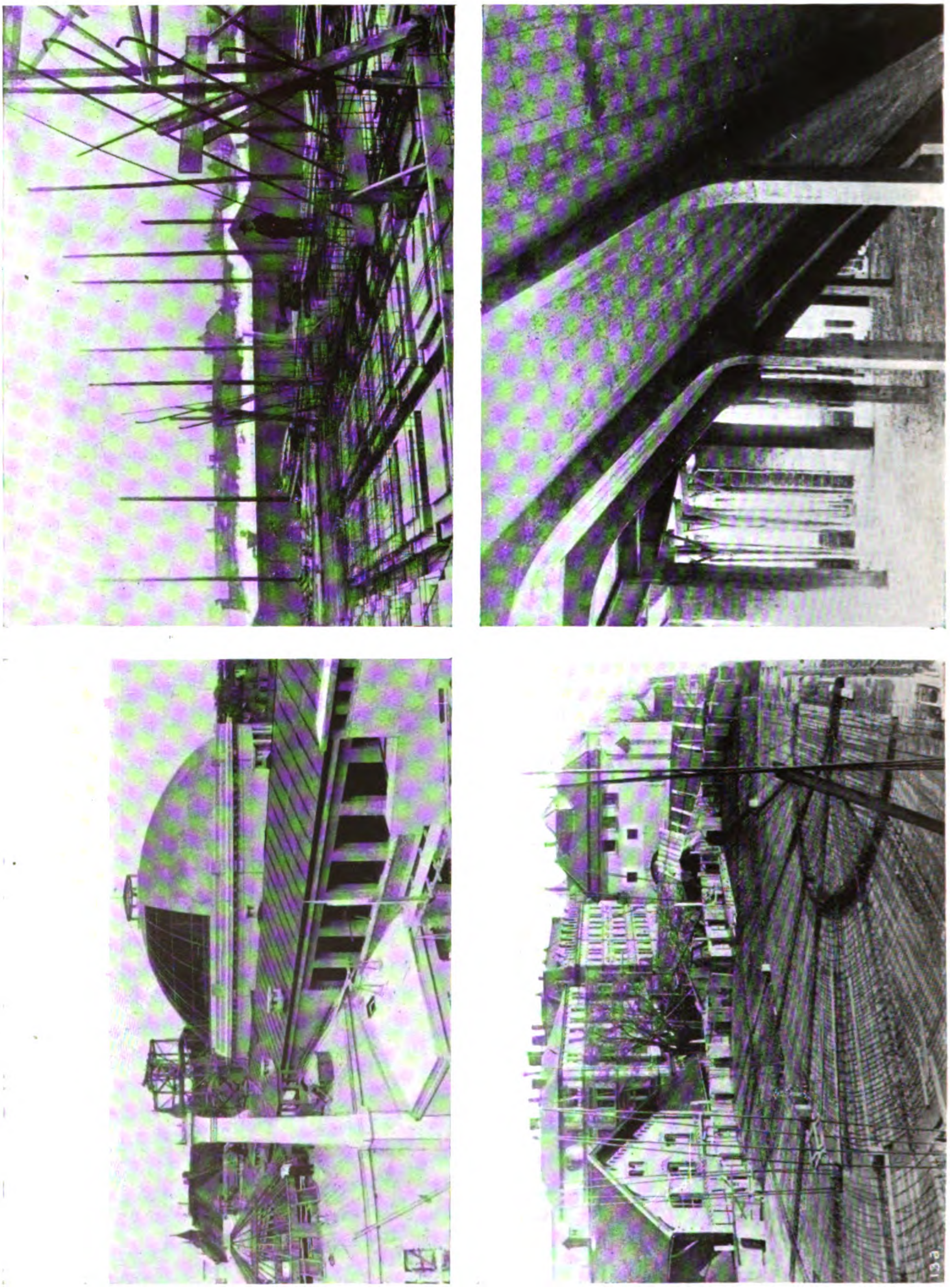
THE SCHOOL OF ANATOMY, MUNICH.
(Plan at third floor level.)

26 a

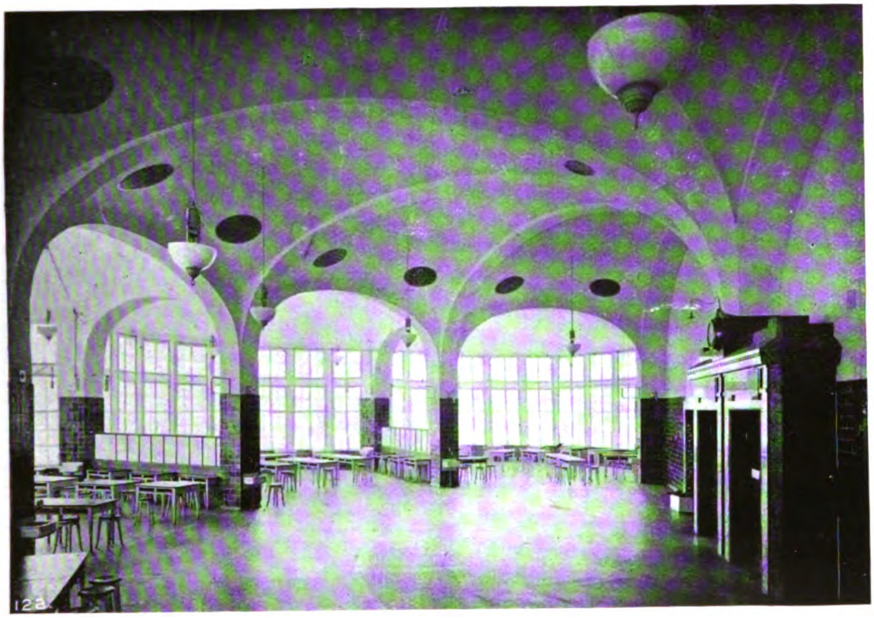


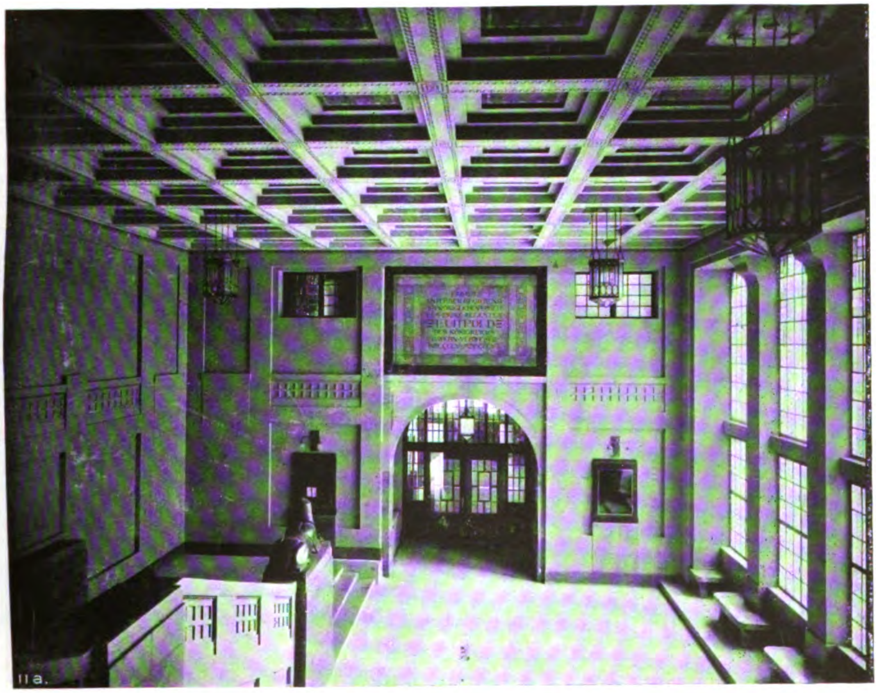
THE SCHOOL OF ANATOMY, MUNICH.
(Plan at first floor level.)

25 a

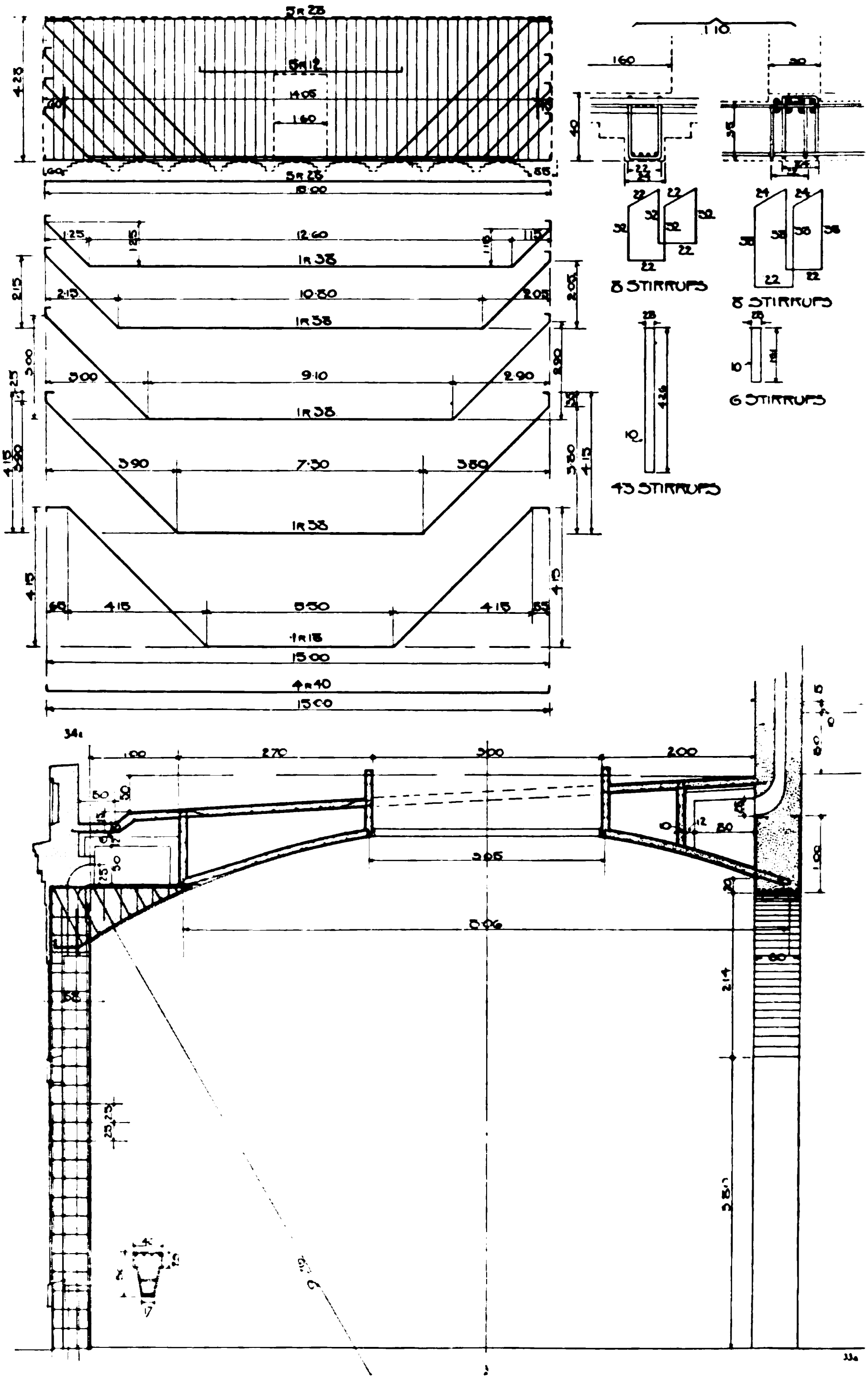


The School of Anatomy, Munich. (Views taken during construction.)

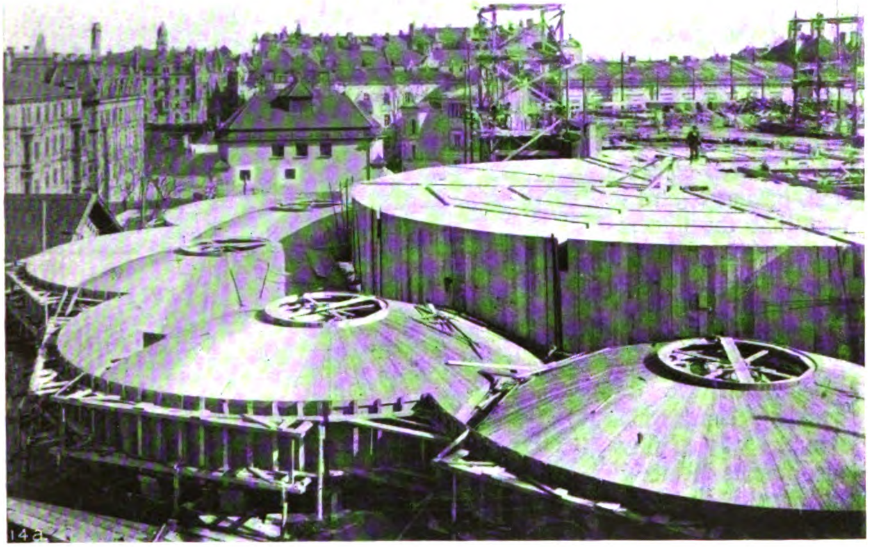




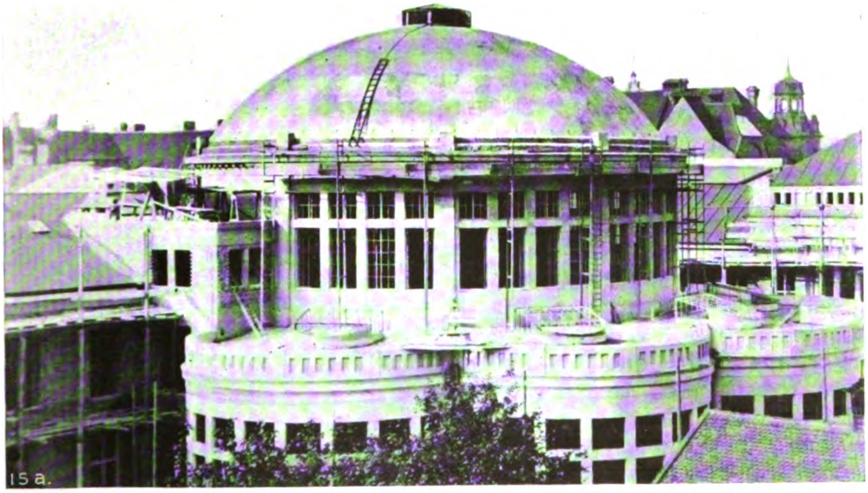
THE SCHOOL OF ANATOMY, MUNICH.
(Interior views.)



The School of Anatomy, Munich (Constructional details.)



CENTERING FOR CUPOLAS.

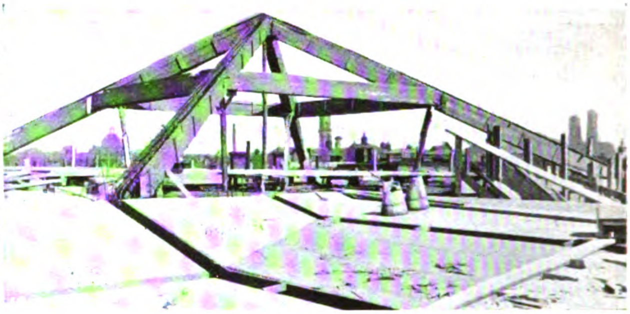


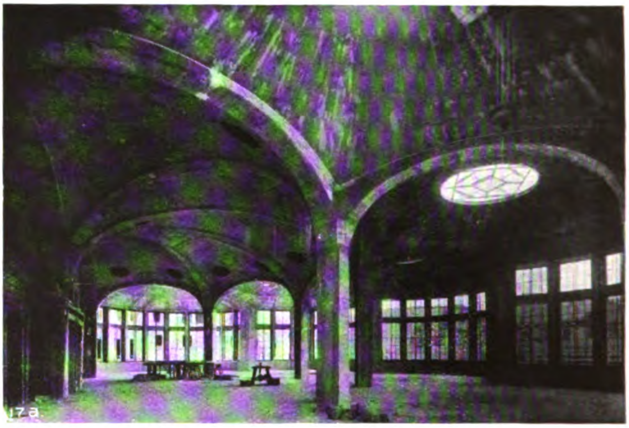
THE SCHOOL OF ANATOMY, MUNICH.
(Exterior views taken during construction.)

It will be seen from the plans and details which we present that reinforced concrete in this structure has been mainly employed for floors and cupolas. It is not, however, our intention to describe the application of reinforced concrete in detail, having regard to the fact that the illustrations have been specially prepared for us, and may be deemed explicit in this direction; but we would indicate that this building, to which we are according considerable space in the way of illustrations, may be deemed to rank amongst the most interesting reinforced concrete structures to be found on the Continent, both from the engineer's as well as from the architect's point of view, and that a close study of the design, both structurally and architecturally, is to be recommended.

We are much indebted to Messrs. Heilmann and Littmann for their courtesy in putting before us their working drawings, in order that we might select such of them as we deemed suitable for reproduction. We also have to thank them for the courtesy of the photographs we are showing.

Perhaps only one further remark need be added, viz.: that Messrs. Heilmann and Littmann are architects who design in reinforced concrete themselves, and then hand over their design to contractors for the purpose of estimates.





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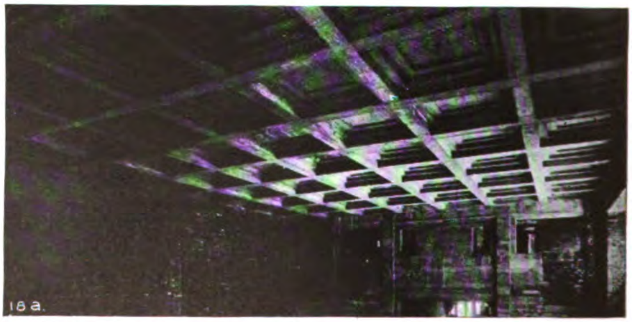


18 a.

THE SCHOOL OF ANATOMY, MUNICH.
(In course of construction.)

Concrete Block-Making in Great Britain.

PART II.

By H. KEMPTON DYSON, C.E.

Although the United States, in particular, has been making great headway of late in the production and use of concrete blocks, both solid and hollow, progress in Great Britain has been somewhat slow in this direction, and we have thus pleasure in presenting some particulars as to the industry in this country in the form of a series of articles dealing with the subject both, historically, as far as patents call for notice, and practically, as far as modern practice and experience are concerned.—ED.

ALTHOUGH a C. S. Hutchinson in 1866, and a Thomas J. Lowry in 1868, had been granted patents in the United States for constructing hollow concrete blocks and walls thereof in a form very similar to those made by machinery at the present time, Mr. H. P. Holt, a civil engineer of Leeds, was the first to take out a full patent in England, which he did in 1875, for hollow concrete block making. *Figs.* 9 to 12 show that he had fully developed the hollow block, though he proposed using wooden moulds. *Figs.* 9 and 10 are part sections part elevations, and *Fig.* 11 a plan of the mould, while *Fig.* 12 shows the blocks used in wall construction; *dd* is a bar which held the cores in position and left holes for hoisting and bonding together.

In the same year, 1875, Mr. J. C. Sellars, a manufacturing chemist of Birkenhead, took out a patent for making hollow concrete blocks which he proposed filling with loose sand and stones or concrete. *Fig.* 13 shows the various forms he adopted and applications suggested. That the advantages of a hollow space had not become generally recognised is proved from the fact that Mr. Sellars advised, as others had done before, that this space should be filled. In the succeeding year Mr. Sellars took out two further patents for improvements in the manufacture. His first patent is for a machine for moulding and compressing solid blocks. This we illustrate in *Fig.* 14.

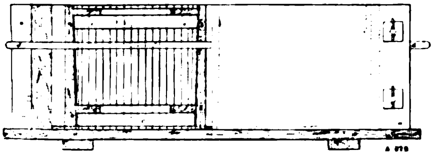


FIG. 9. Part elevation, part section of Holt's mould for hollow blocks.

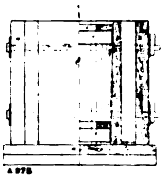


FIG. 10. Part end elevation, part section of Holt's mould.

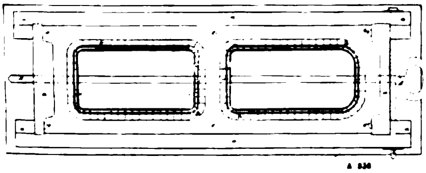


FIG. 11 Plan of Holt's mould.

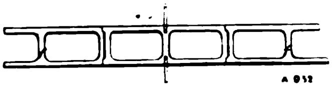


FIG. 12. Plan of wall constructed with Holt's blocks.

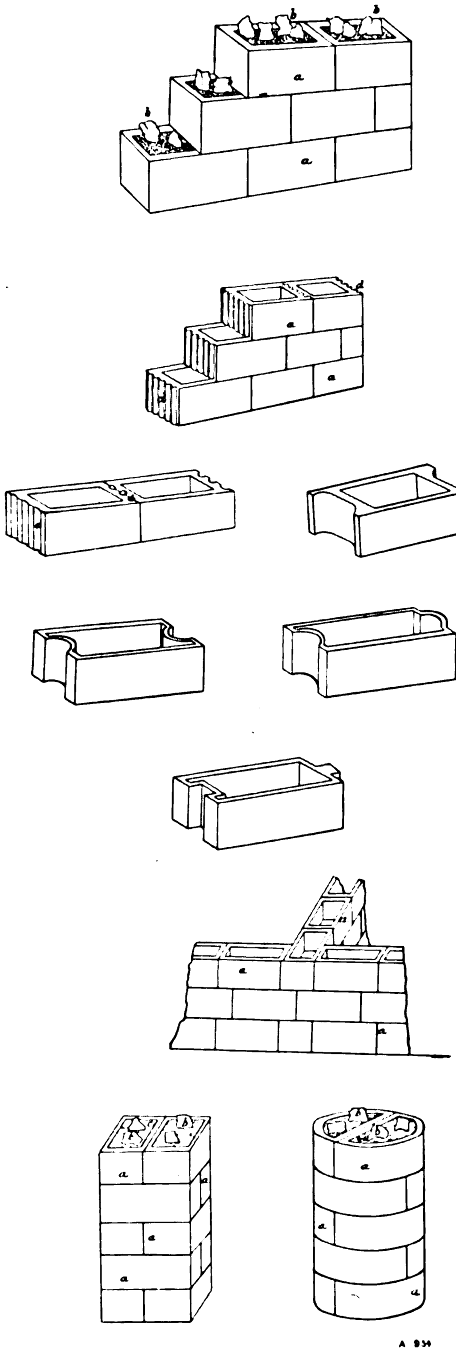


FIG. 13. Drawings from Sellars's 1875 Patent.

The other patent is for other forms of hollow blocks different to those he first thought of, together with methods of moulding them; *Fig.* 15 shows these. He followed in 1877 with three more patents embodying improvements in form and manufacture. The last describes a machine for moulding and compressing hollow blocks, and is illustrated in *Fig.* 16. Mr. Sellars was therefore the first to invent a machine for block-making.

The question of speed and economy in the moulding of concrete blocks is an important one, but it was not until recent years that much attention seems to have been paid to this side of the subject. The writer remembers seeing a machine being used by a speculative builder about twelve years ago at Clacton-on-Sea for the making of solid concrete blocks for the erection of a number of houses. The blocks were cubes about 12″ on each face, and, as far as recollected, the sides of the moulds could be turned down on hinges so as to remove the block on a base-plate. The moulds were of cast-iron, and the concrete was rammed by means of a plunger screwed down by a wheel similar to Mr. Sellars's machine. But the usual method of moulding blocks at that date was to use wooden moulds, and a factory was constructed from the writer's designs at Battersea some ten years ago, in which this method of moulding concrete blocks, of which the walls were built, was used. H. S. Palmer, of Washington, U.S.A., took out a patent in 1900 for what appears to be the first modern type machine for making hollow concrete blocks, and it was not until a few years ago that such machines were introduced into England.

It was somewhere about 1870 that several firms were established for the manufacture of artificial stone, consisting of moulded concrete, and solid blocks of various sizes and shapes were used for dressings, and, in some cases for erecting walls entire. These blocks were all cast on the bench in wooden moulds, and any mouldings that were placed thereon were, as a rule, run in plaster in the reverse and placed within a box mould.

Mr. Edward Bow was one of the earliest artificial stone manufacturers. He formed the Bowstone Company, whose works were at Maidstone, and supplied dressings, etc., to many important mansions in Kent, beginning with Wrinstead Court, Lenham, in 1853. *Fig.* 17 shows Torry Hill House, erected for Lord Kingsdown in 1856, to which Mr. Bow supplied concrete block dressings. This firm introduced an L-shaped building block in 1892, which was used as shown in *Figs.* 18 and 19. For this information I am indebted to Mr. Reavell, London manager to Hodkin & Jones, Ltd., of Sheffield, who are also old-established artificial stone makers, and who also introduced an L-shaped facing block

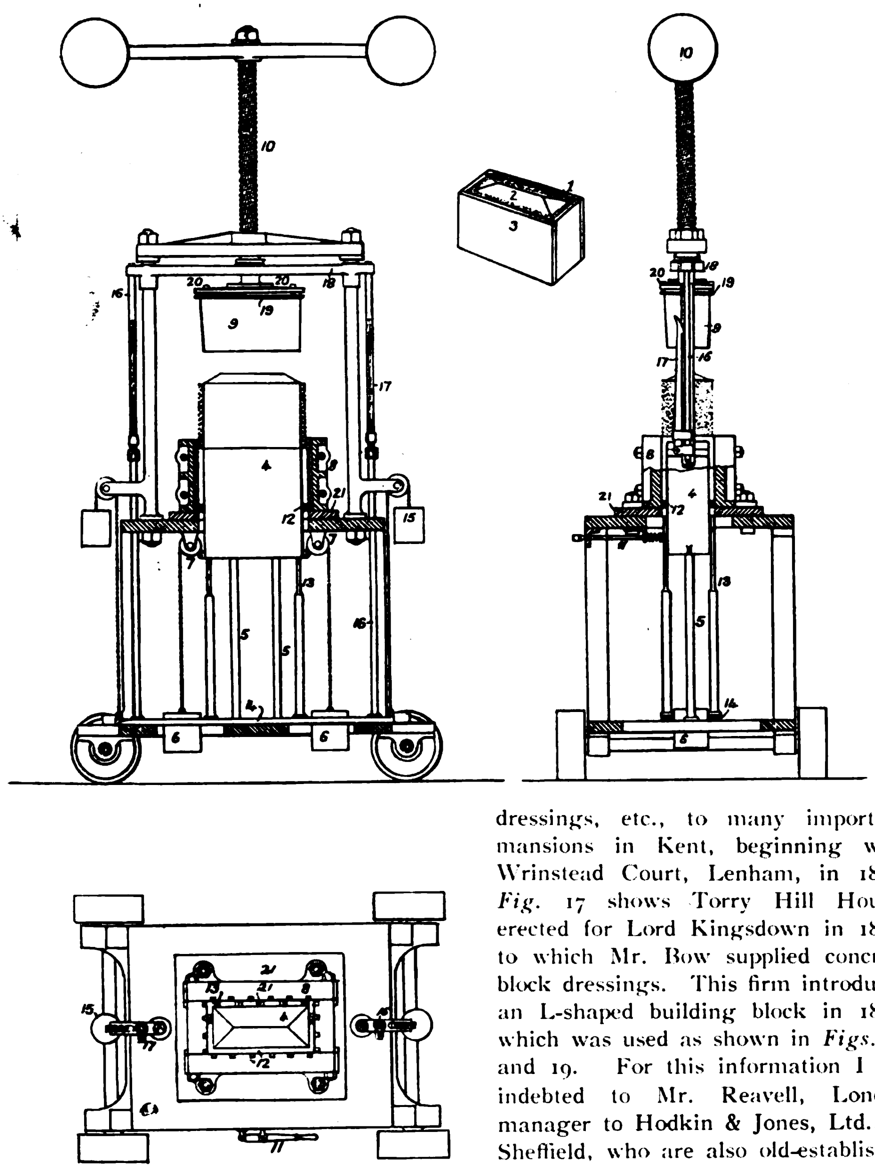


FIG. 14. Sellars's 1876 patent machine for moulding solid blocks.

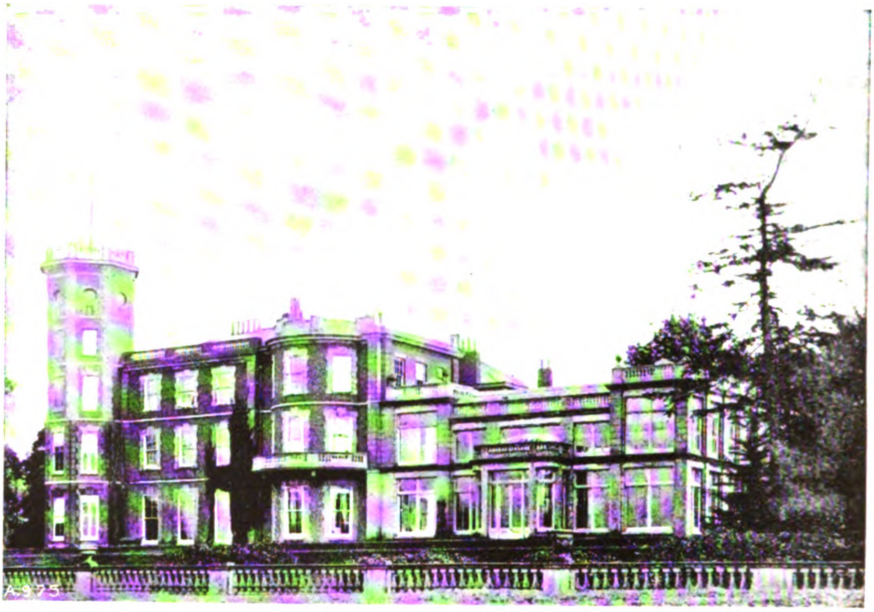


FIG. 17. Torry Hill House, Lenham, Kent, erected in 1856 for Lord Kingsdown, with concrete block dressings supplied by Edward Bow.

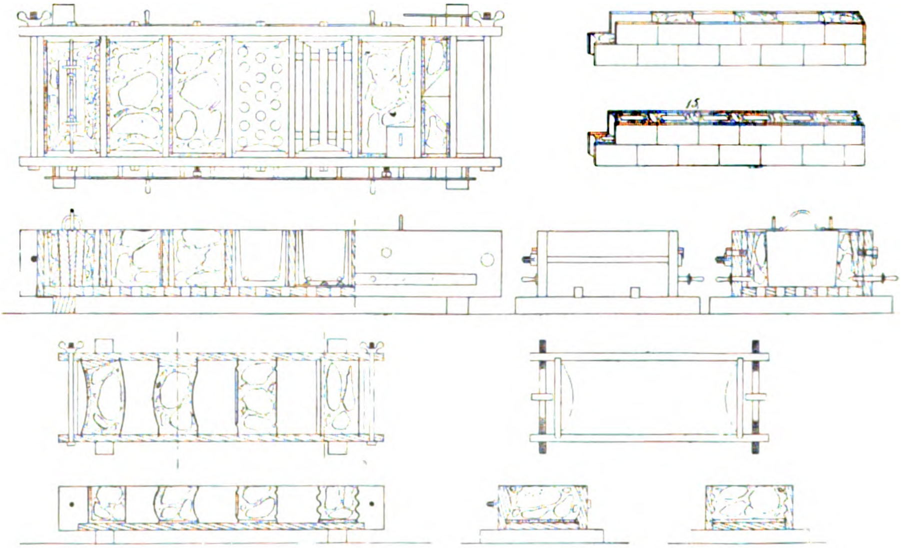
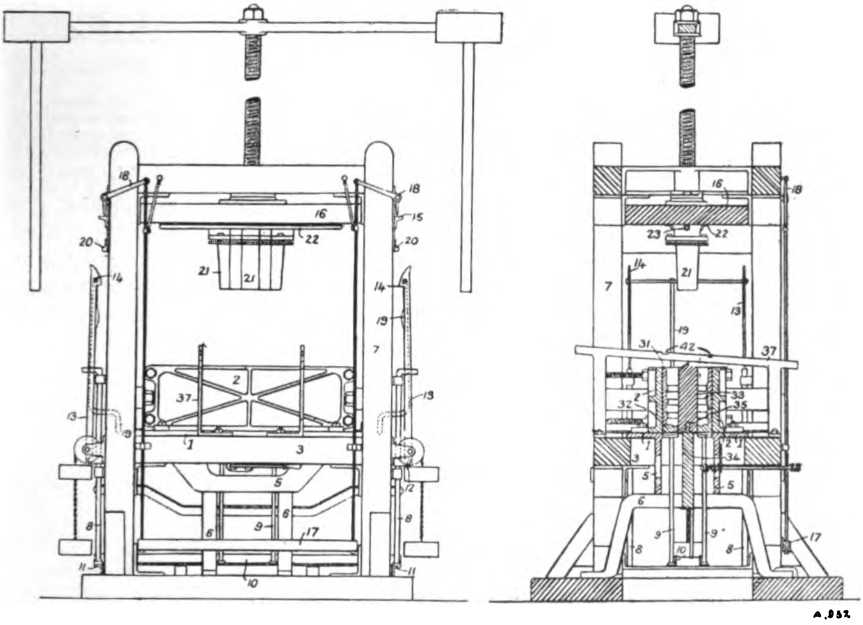


FIG. 15. Drawings from Sellars's 1876 patent for hollow blocks.

some years ago, which, however, was somewhat different because the base extended right through the wall and bricks were laid between it and the next block.

Messrs. Stuart's Granolithic Co., Ltd., have made artificial stone blocks for houses and other buildings for more than 35 years past, chiefly consisting, however, of dressings to brick fronts, comprising plinths, sills, bands, heads, strings, beads or neckings, cornices, blocking courses and copes. The largest dock—until quite recently, when another came to share the distinction—in the country, namely, the Govan Dock at Glasgow, was constructed practically of their blocks, under Mr. Deas, the Chief Engineer. Messrs. Stuart manufacture their artificial stone where it is of sufficient scantling with 3 to 1 specially crushed stone, and, with the cement facing in "Granolithic" (*i.e.*, fine crushed granite and cement) 2 to 1; but where the scantling is small, say for instance, 9 in. by 4 in. cills, or where for heavy work great loads are to be supported, then "Granolithic" purely enters therein. Three tones are made: grey (the natural colour), red (varying in shade), and buff. These colours are permanent, others are not.



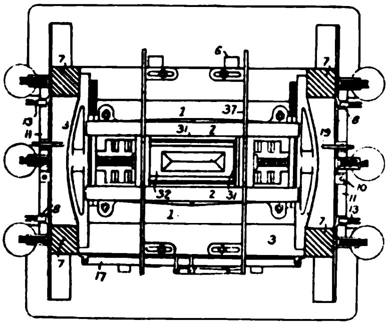


FIG. 16. Sellars's 1877 patent machine for moulding hollow blocks.

The Patent Victoria Stone Co., Ltd., which has also done much work in artificial stone dressings, etc., was established in 1868.

The weight of solid concrete blocks is, however, considerable. When they are used the building is a sort of masonry, the fixing is troublesome, and the cost does not show any material advantage over brickwork. For this reason the solid concrete

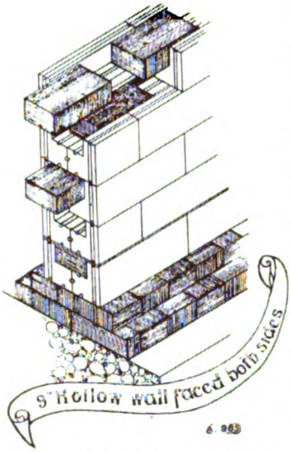


FIG. 18. L-shaped concrete facing block introduced by the Bowstone Co., as applied to 9-in. wall faced both sides.

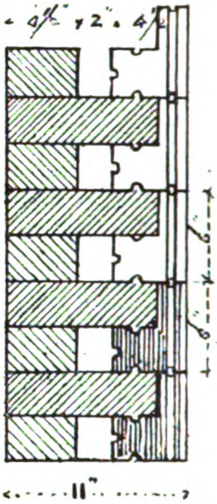


FIG. 19. Bowstone L-shaped block as applied to 11 in. wall backed by brickwork.

block did not make much progress except for engineering structures where large blocks are required to resist the lifting action of the waves in breakwaters and harbours, etc. But this aspect of the subject, although it comes under the general title of this article, is not that which is generally understood to be concrete block building to-day.

An allied form of construction, which it is necessary for us to refer to, is the use of concrete slabs for constructing the walls of buildings. The late Mr. W. H. Lascelles, whose firm is well-known to-day as large London contractors, brought out a system of erecting buildings with a timber framework of 4 in. by 3 in. uprights, 3 ft. apart, upon which were screwed, each with 4 screws, concrete slabs about 1¾ in. thick, and he published in 1878 a book entitled "Sketches for Cottages and other Buildings designed to be Constructed in the Patent Cement Slab System of W. H. Lascelles, 127 Bunhill Row, Finsbury, London, E.C. From Sketches and Notes by R. Norman Shaw, R.A., drawn by Maurice B. Adams, A.R.I.B.A.," and followed it in 1881 with a further set of sketches for cottages, etc., by Mr. Norman Shaw and Mr. Ernest Newton. A number of cottages were erected at Croydon based on Mr. Shaw's and Mr. Newton's designs, and are still owned by the Lascelles family. Some we illustrate in *Fig.* 20. Perhaps the finest house is that known as "The Retreat," 20 Friends Road, Croydon, illustrated in *Fig.* 21. It will be seen that the slabs give the exact appearance of vertical tiling, the surfaces being coloured red in imitation of tiles, and their present condition shows how excellent the Lascelles slabs were. The use of these slabs was tried for roofing, but they were found to be too heavy for economy and convenience. In some of the Croydon houses the floors are formed of concrete slabs, supported on small wooden beams, which are exposed and give a fine panelled ceiling, being moulded on the edges. An interesting fact in connection with these houses may be mentioned. When the slabs were first being made, in order to allow them to be removed from the moulds more speedily, and not to permanently strengthen them, pieces of iron ¼ in. square in section were placed diagonally across the slab, and, occasionally, smaller iron rods ⅛ in. sq. were placed

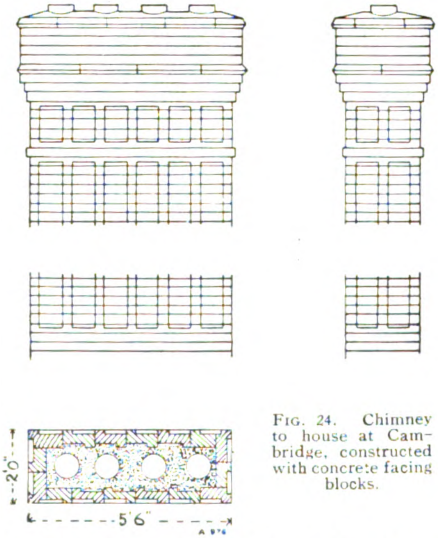


FIG. 24. Chimney to house at Cambridge, constructed with concrete facing blocks.

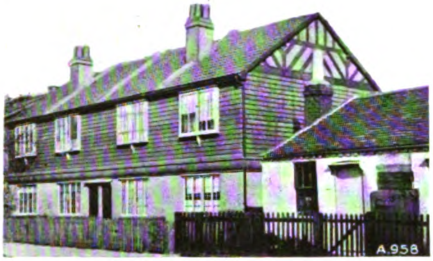


FIG. 20. Block of Lascelles concrete slab cottages at Croydon.

across these again, as shown in *Fig. 22.* Their use was afterwards abandoned. The concrete of which these slabs was made was composed at first of 4 parts coke breeze to 1 of cement, and afterwards of clinker and Portland cement in the proportion of 3 to 1. It was found after a short while, not more than two or three years, that wherever the slabs had been reinforced with these rods surface cracks appeared along the lines of the rods, and some of the houses at Croydon now show how detrimental this was, from the fact that the air got in and rusted the rods, so flaking off the outer surface of the concrete in places. The writer is not able to account for these cracks, because the concrete was well made; the cracks occurred long before there could have been any rusting; and, indeed, the reinforcements existing in some of the slabs to-day, although within only about half an inch of the surface, are entirely free from rust. He has examined some of the slabs which had been broken up in demolishing a stable

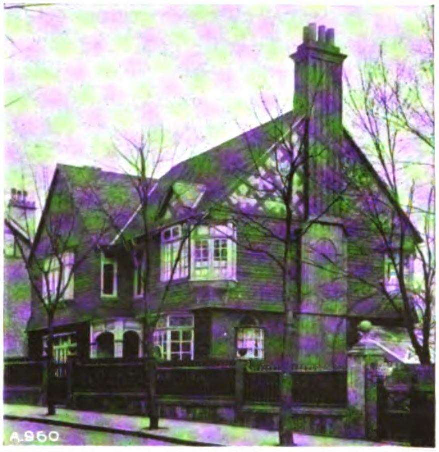


FIG. 21. "The Retreat," 20 Friends Road, Croydon, constructed on Lascelles concrete slab system.

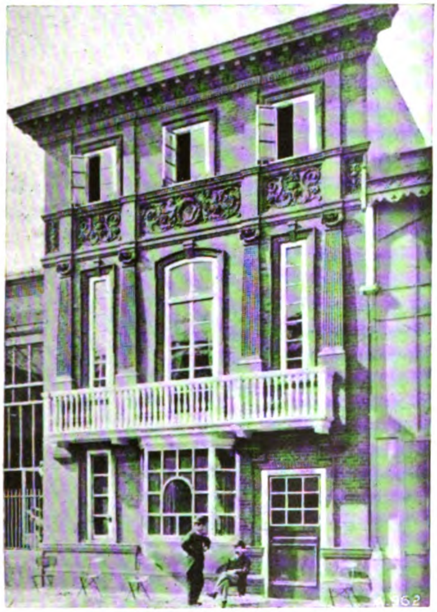


FIG. 23. Façade designed by Norman Shaw, R.A., and constructed in Lascelles slabs coloured and lined up to imitate brickwork, erected at the Paris Exhibition of 1878.

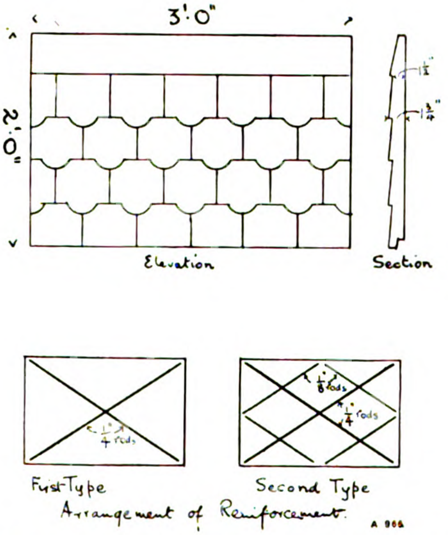


FIG. 22. A Lascelles concrete slab, with details showing arrangement of reinforcement.

erected therewith, and found these reinforcements in excellent condition, so that presumably the concrete is not at fault, nor is it sufficiently porous to have caused any rusting to occur. Concrete and steel are supposed to have the same coefficient of expansion; therefore, the cracks ought not to have occurred from this cause. Satisfactory explanation is therefore wanted, because this instance seems to show a peculiarity in the behaviour of reinforced concrete which may have an important bearing upon modern structures.

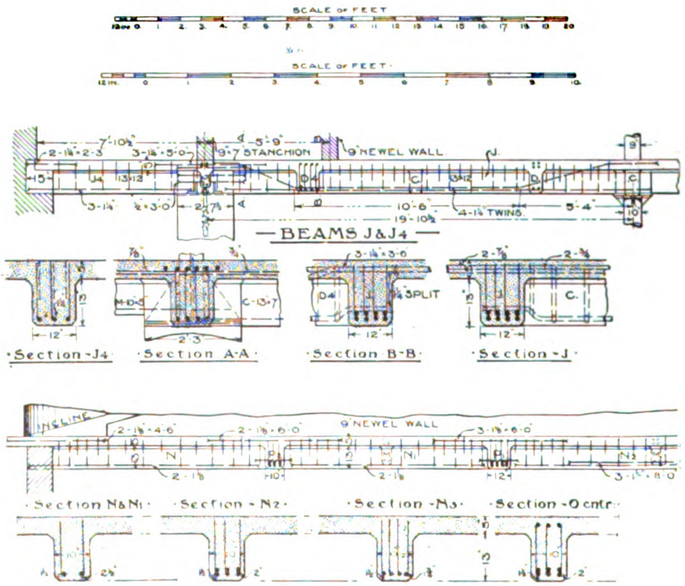
Mr. Lascelles exhibited a cottage built of slabs at Paris which was afterwards erected at St. Cloud. He also erected the pavilion, designed by Mr. R. Norman Shaw, R.A., and illustrated in *Fig.* 23, at the Paris Exhibition of 1878. This is not brickwork, but concrete coloured red and lined up like brickwork. This exhibit gained a gold medal and Legion d'Honneur.

An early building in Lascelles slabs was that erected about thirty years ago at Knight, Bevan & Sturges's Cement Works at Northfleet.

The use of this method of building has been carried on for many years past, and is being carried on to-day by Messrs. W. H. Lascelles & Co., of 127 Bunhill Row, London, E.C. The buildings erected recently with these slabs are as follows:—(1) General offices and the central buffet, Peninsular & Oriental Offices at the Royal Albert Dock in London (Messrs. Vigors & Wagstaffe, architects). The walls are solid concrete below, with the upper part of slab construction. (2) A house at Tongue, N.B., for the Duke of Sutherland (Mr. H. A. Rye, architect).

Messrs. W. H. Lascelles & Co. constructed some cottages at Hatfield for the Marquis of Salisbury, about 1887, with hollow concrete blocks, shaped as a square hollow space by raising above bed, which were cast in wooden moulds. The hollows were formed by placing in the moulds a wooden core made of three pieces of wood, the centre being of wedge-shape so as to allow the core to be removed easily. *Fig.* 24 shows some solid concrete facing blocks of novel form made by this firm for a house at Cambridge, erected for the Rev. H. Latham many years ago.

(*To be continued.*)



Reinforced Concrete Stores and Stables
(Details of ground floor and first floor.)

REINFORCED CONCRETE STORES AND STABLES IN LONDON.

We are presenting herewith particulars of a reinforced concrete structure used as a warehouse and stables.

Where the plan of building is free from complication and difficult angular features, it will generally be found that reinforced concrete is economical.

Besides showing drawings, we are presenting three photographs of the work as completed.—ED.

Reinforced Concrete Stores and Stables.
(View of Stalls).

A very interesting example of reinforced concrete work in the City is the building used for storage purposes and as stables at the rear of Nos. 70-74, Whitecross Street, erected for Messrs. Sutton & Co., the well-known carriers, by Messrs. F. Bradford & Co., Homerton, N.E., to the designs of Mr. E. P. Wells.

The architect was the late Mr. John Hamilton, of London.

DESCRIPTION.

The building consists of a basement, ground and first floors and loft, and lifts work from the basement to the first floor.

In *Fig.* 1 is shown a basement plan with beams supporting first floor and accompanying details.

The first floor, *Fig.* 2, is over 1,500 yds. super, and is constructed entirely in reinforced concrete. The floor is 5 in. thick, with a granolithic finish, and is used by horses and vans for loading purposes. The concreting was completed in thirty-three days.

The framework of the building is partly steel, the girders being shown by thick black lines on *Fig.* 2, with cast-iron columns, and the columns are not bolted together, the upper columns simply resting on the lower ones, the concrete holding them in position. The steel beams are connected to the columns in the usual way, and are cased in concrete down to the lower flange. The load was 2 cwt. per sq. ft. on all floors (ground, first and loft), plus the dead or static load. In some cases the beams have to carry brick walls, as in the case of the inclines and the floors over, and in all cases the full live load was allowed for, the steel being stressed to 8 tons per sq. in. of sectional area.

The concrete was 5 to 1, *i.e.*, 3 parts of crushed ballast, 2 of Thames sand, and 1 of Portland cement.

The horse runs, which are shown in *Fig.* 3, are in reinforced concrete, and the walls are built on the concrete floor and carried on the beams under.

The stables on the ground floor have 31 ft. 11 in. centres, and carry, in addition to the weight of horses, etc., a 9-in. brick division wall, extending nearly the whole

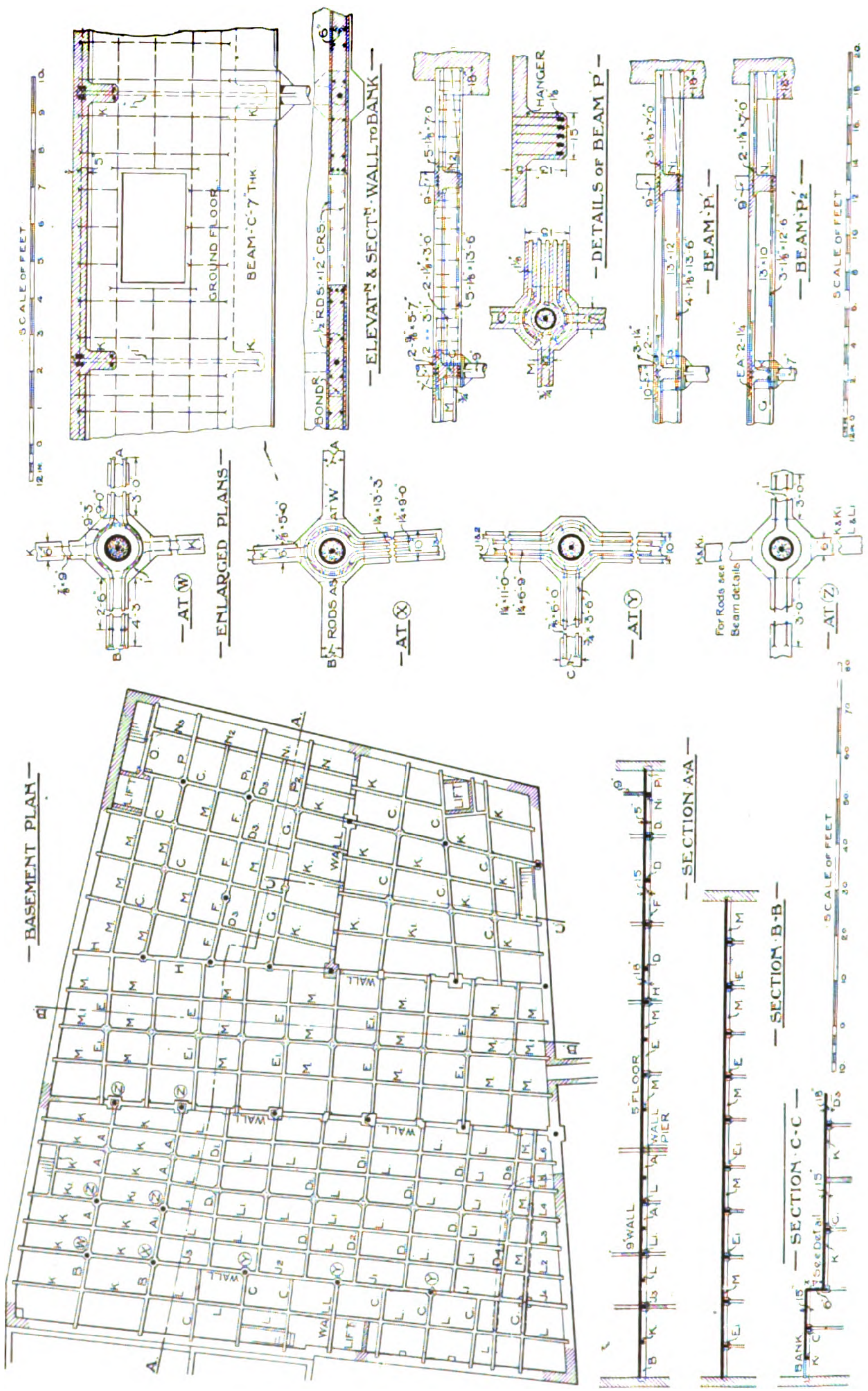


Fig 1. Basement Plan, showing Beams at Ground Floor.

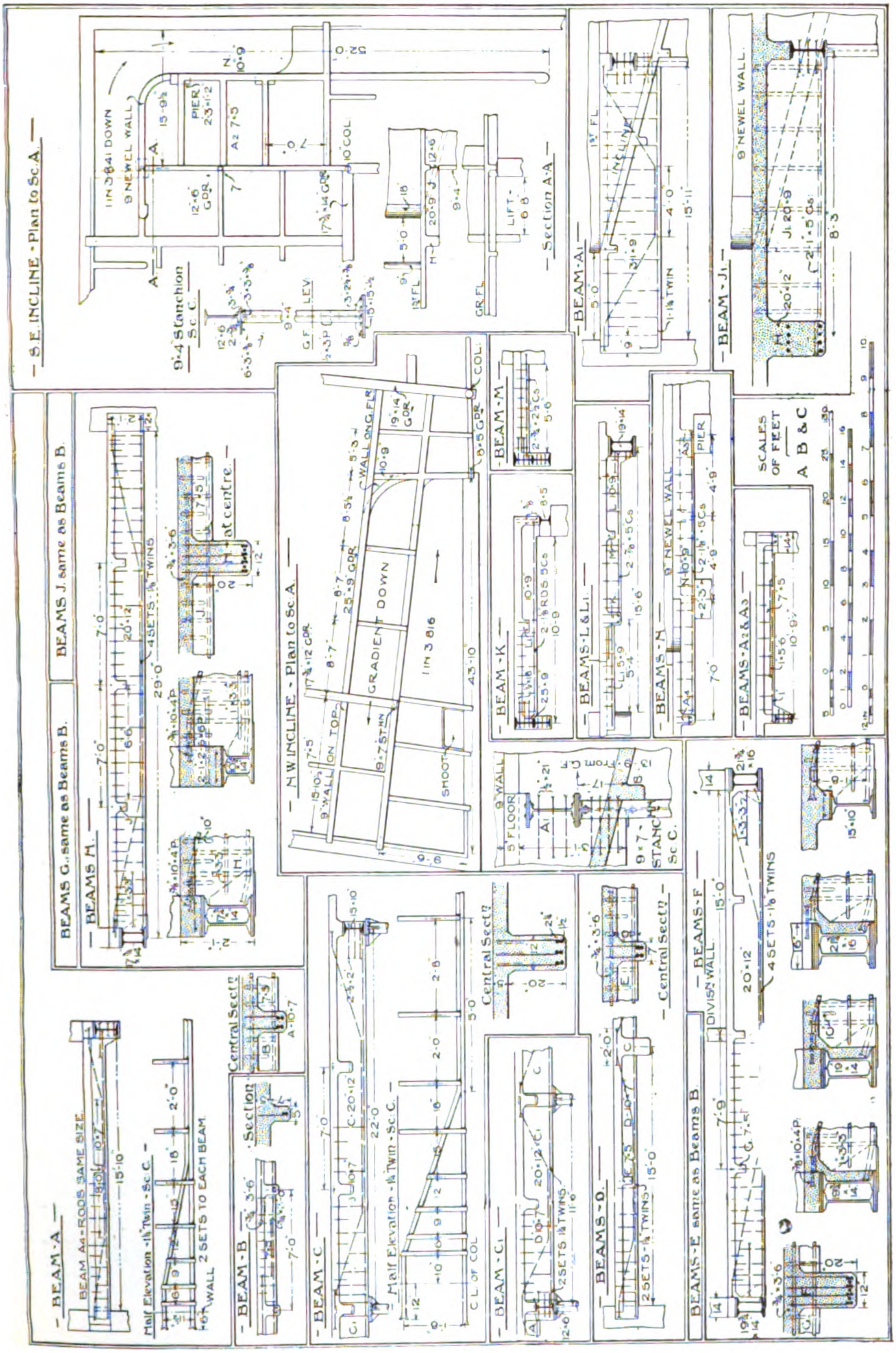
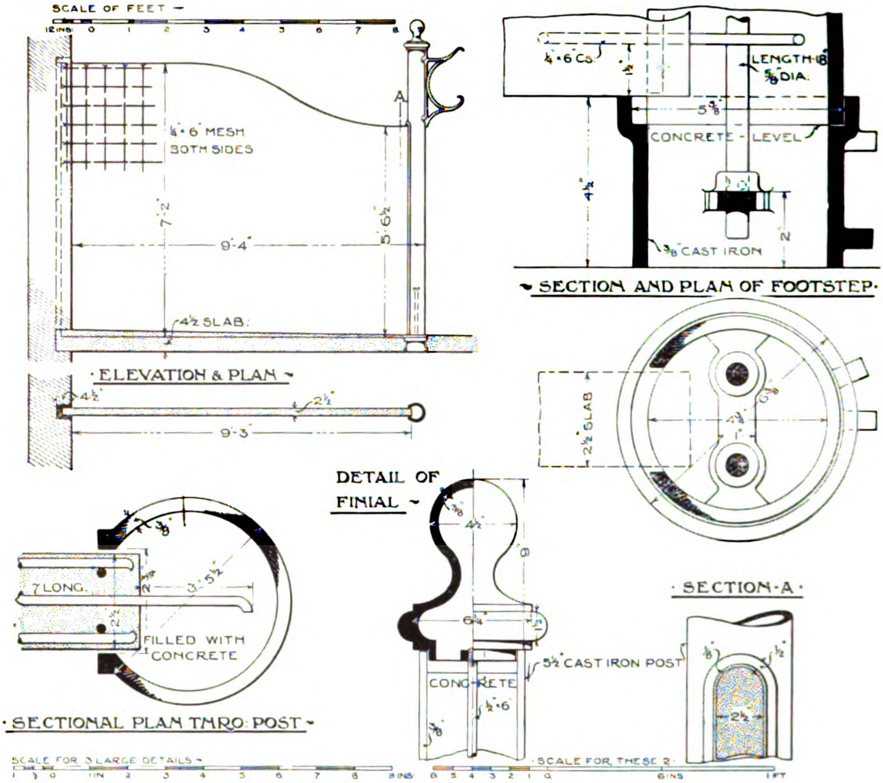
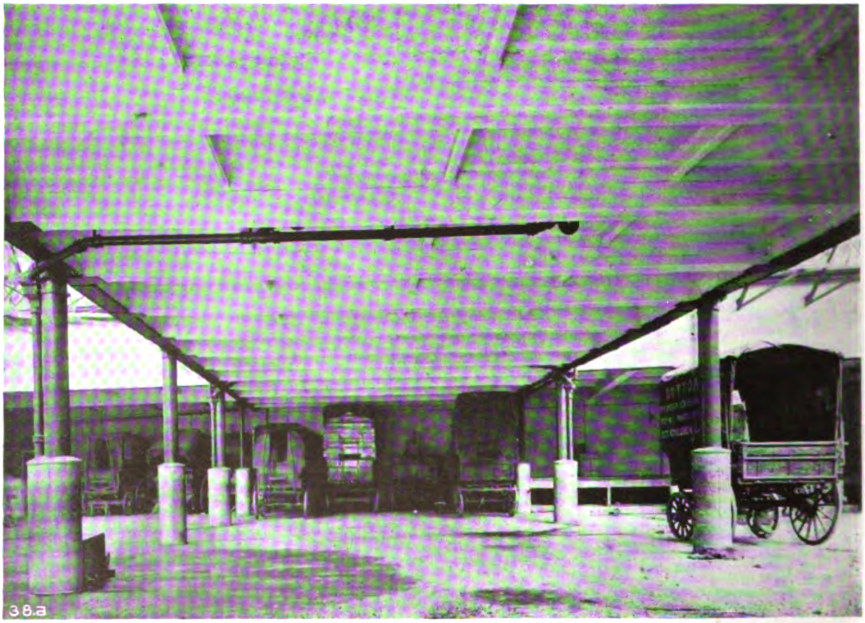


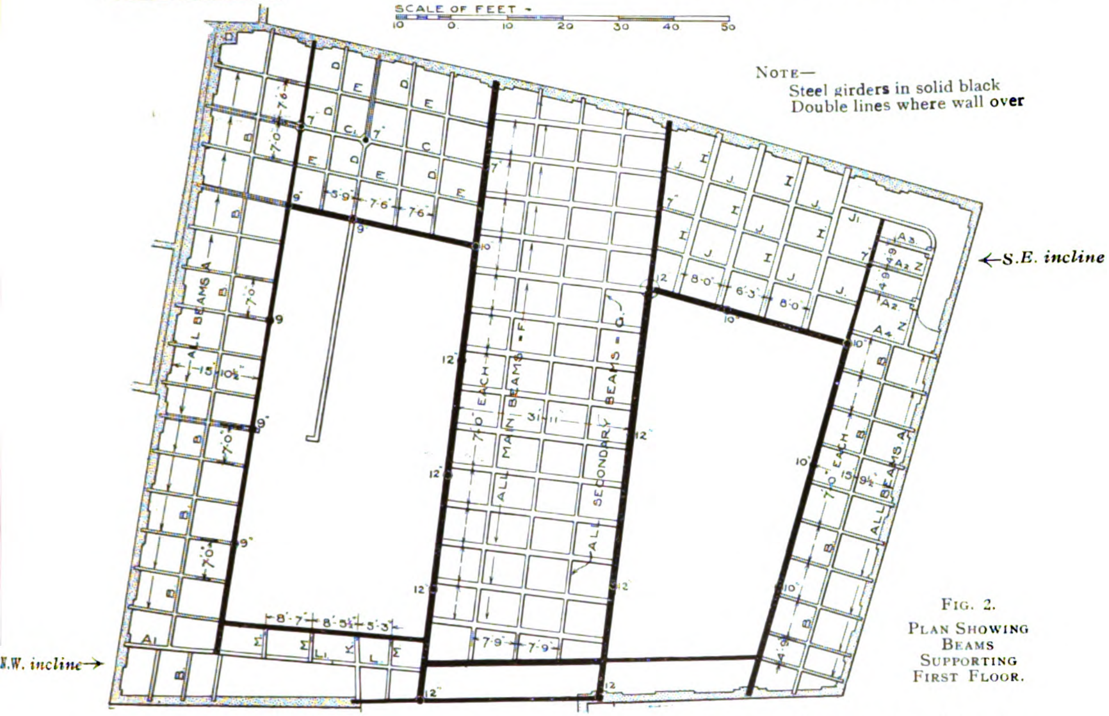
Fig 3. Details of Reinforced Concrete Beams, etc., for First Floor.



Details of Reinforced Concrete Stalls, etc.



Reinforced Concrete Stores and Stables.



Note—
Steel girders in solid black
Double lines where wall over

Fig. 2.
Plan Showing
Beams
Supporting
First Floor.

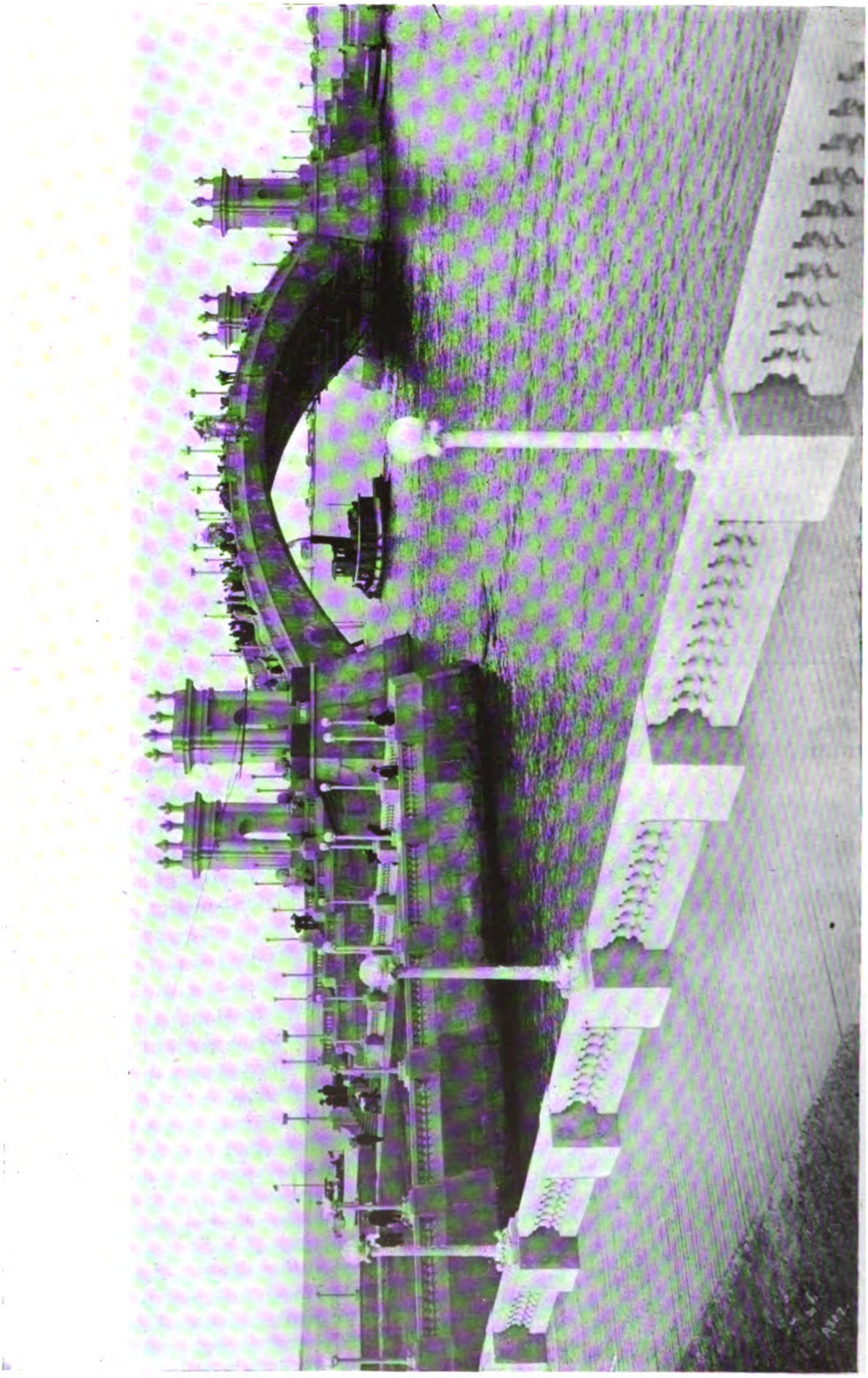
length of the stables. The stall post and stable fittings were specially designed in reinforced concrete, and all divisions are in reinforced concrete 2½ in. in thickness. The construction of this first floor occupied exactly two months.

Above the first floor central stables is situated the loft, the principal beams of which will be found in detail in the illustrations presented.

The entire building is intended to be fire-resisting with the exception, curiously, of the roof, which is, round the sides and over the hay-loft, composed of heavy timber, the large opening over the area being roofed with steel principals and glass.

For the plans and some of the particulars given we are indebted to Mr. E. P. Wells, and for the photographs and additional notes to Messrs. Bradford & Co.

Reinforced Concrete Stores and Stables.
(An interior view of the stores below ground floor.)



Reinforced Concrete Bridge and Pier at the Jamestown Exhibition.

SOME RECENT CONCRETE AND REINFORCED CONCRETE BRIDGES, VIADUCTS, ETC., IN THE UNITED STATES

1a

South Bridge, Columbian Park, Lafayette, Indiana.

In our March issue we published a number of illustrations of Reinforced Concrete Bridges in Italy. We have now pleasure in presenting some instances of recent bridges and viaducts in the United States and printing a short description of each.

We wish to acknowledge our indebtedness for photographs and particulars to our contemporary "The Cement Age," of New York; to the National Bridge Co., of Indianapolis, U.S.A.; and to the Patent Indented Steel Bar Co., Ltd., of London.—ED.

GENERAL DESCRIPTION OF BRIDGES.

Reinforced Concrete Bridge and Pier at the Jamestown Exhibition.—But little has been published in Europe regarding the reinforced concrete work at the Jamestown Exhibition, which work was not only extraordinary in extent but of technical and artistic interest. The principal part of this reinforced concrete work was a pier consisting of two arms, each 150 ft. wide and 1,200 ft. long, connected at the outer end by a reinforced concrete arch of considerable architectural merit. Two wings extend along the shore a distance of 500 ft. on either side of the pier, the shore end over all being about 1,400 ft. long. The area enclosed by the two piers formed a sheltered harbour for small craft. Retaining walls of reinforced concrete were first built around the entire area to be filled, and the material from between the piers pumped up into these areas. About 4,000 piles and 12,000 sheet piles were used, and the dredged material pumped into the piers was no less than 250,000 cu. yds.

The reinforced concrete arch of the bridge, which was of single span, was 152 ft., with a height of 25 ft. and a width of 30 ft. It comprised two main girders, 3 ft. deep at the crown and increasing to 6 ft. at the haunch, the reinforced concrete floor-slab on these girders being 12 in. thick.

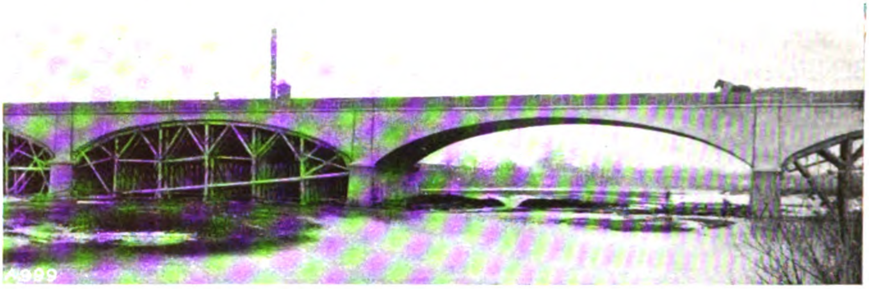
To give an idea of the size it must be realised that in the illustration opposite the distance from the side of the pier on the left of the picture to the side just showing on the right is 550 ft.

South Bridge, Columbian Park, Lafayette, Indiana. — This bridge was constructed by the National Bridge Co., to a span of 40 ft. and with a rise of 4 ft. The height of the opening is 8 ft., the roadway 6 ft., the crown 10 ft. The pavement rods are $\frac{3}{4}$ in. spaced 12 in. in 6 in. concrete pavement. The arch rods are $\frac{3}{4}$ in. and spaced 12 in. The bridge was designed to carry a load of 100 lbs. per sq. ft.

2a

Pike Street Bridge, Pontiac, Michigan.
(Erected for the City of Pontiac.)

Pike Street Bridge, Pontiac, Michigan.—This bridge was constructed by the same firm, and has a span of 30 ft. to a rise of 6 ft. The opening is 7 ft. 6 in., the roadway 60 ft., and the crown 12 in. The pavement rods are ¾ in., spaced 3 ft. 6 in. in a concrete pavement. The arch rods are ¾ in. and spaced 3 ft. The bridge was designed for a 20-ton road roller, or 200 lbs. per sq. ft.



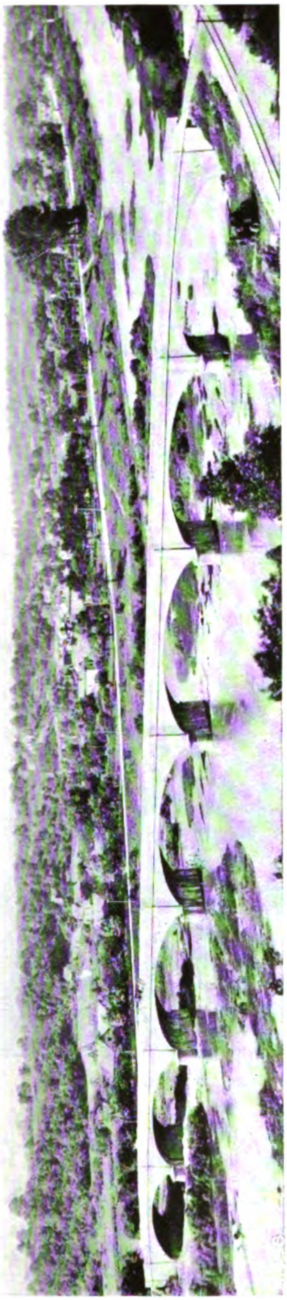
WAYNE STREET BRIDGE, PERU, INDIANA.
(Erected for the Board of Commissioners of Miami County.)

Wayne Street Bridge, Peru, Indiana.—This Bridge was also constructed by the same firm, and has seven spans ranging from 75 ft. to 100 ft., with a rise of 13 ft. 6 in. to 15 ft. 4 in. The height of the openings are 24 ft. to 28 ft. The roadway is 30 ft., the crown thickness 21 to 25 in., and the piers are 6 ft. thick at springing. The arch rods are ¾ in., spaced 6 to 12 in. The pavement rods are 1 in., spaced 12 in. in 6 in. concrete pavements in end spans only, since thrusts are balanced on all piers. Pavement in end span diverts current to the main spans, and the foundations are on

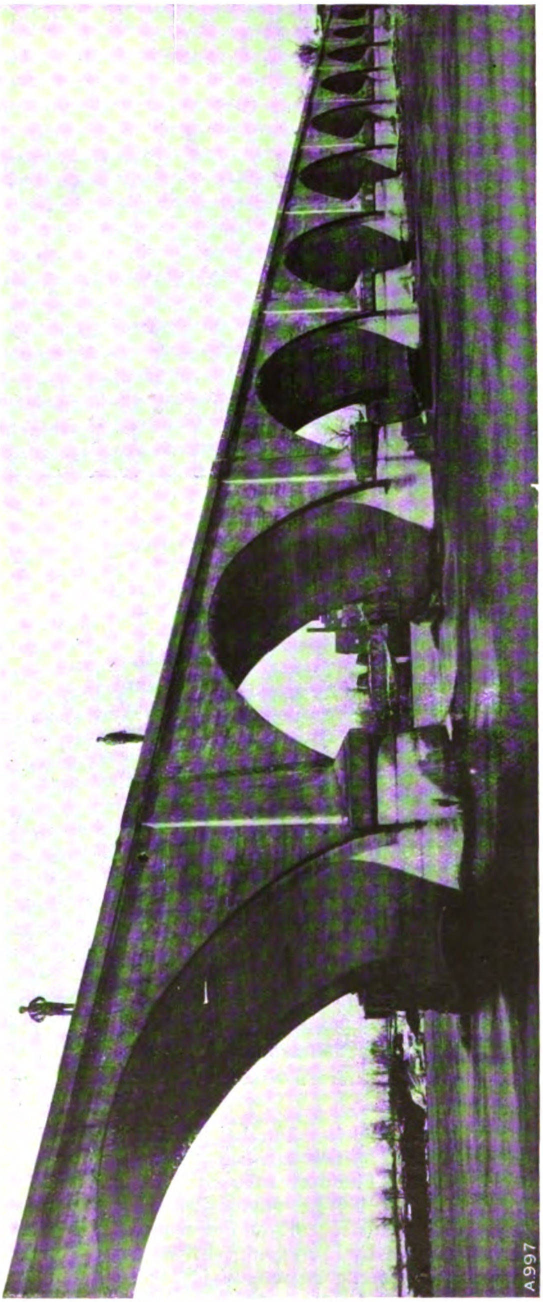
MAUMEE BRIDGE, WATERVILLE, OHIO.
(Erected for the Ohio Electric Railway Co., Cincinnati.)

rock 16 ft. below bed of river. The bridge was designed for a 20-ton road roller, and 200 lbs. per sq. ft.

For efficiency and appearance spans were increased towards middle of river,



WAYNE STREET BRIDGE, PERU, INDIANA.

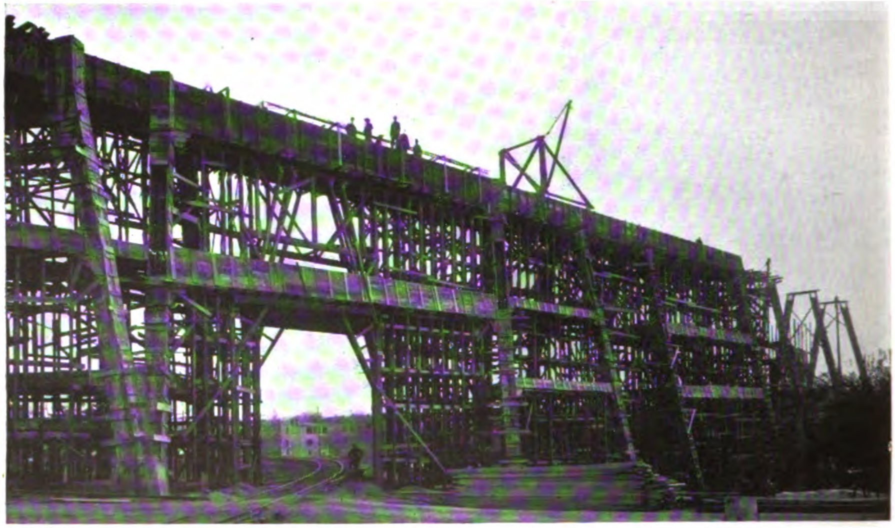


MAUMEE BRIDGE, WATERVILLE, OHIO.

but since the Wabash River at this point rises in flood time to within 5 ft. of crown of main arch, it was impossible to balance thrusts of unequal arches by flattening of the shorter spans. The contents of the bridge are about 5,000 cu. yds. of concrete and 100,000 lbs. of steel. The bridge took just over six months to erect.

Maumee Bridge, Waterville, Ohio.—This bridge was also constructed by the National Bridge Co., and has 12 spans ranging from 75 ft. to 90 ft., with a rise of 22 ft. 3 in. to 25 ft. The height of openings is from 35 to 40 ft., with a roadway 16 ft. at subgrade. The crowns are 24 in. on all spans, while the piers are 10 ft. at springings. The arch rods are 1 in. spaced 6 in. The foundations rest on rock at bed of river. The bridge was designed for 200-ton cars in train.

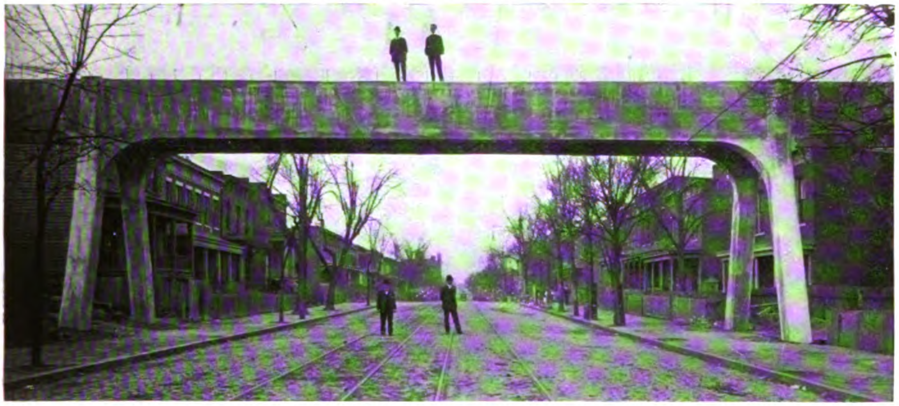
(The viaduct at this point is 70 ft. high.)

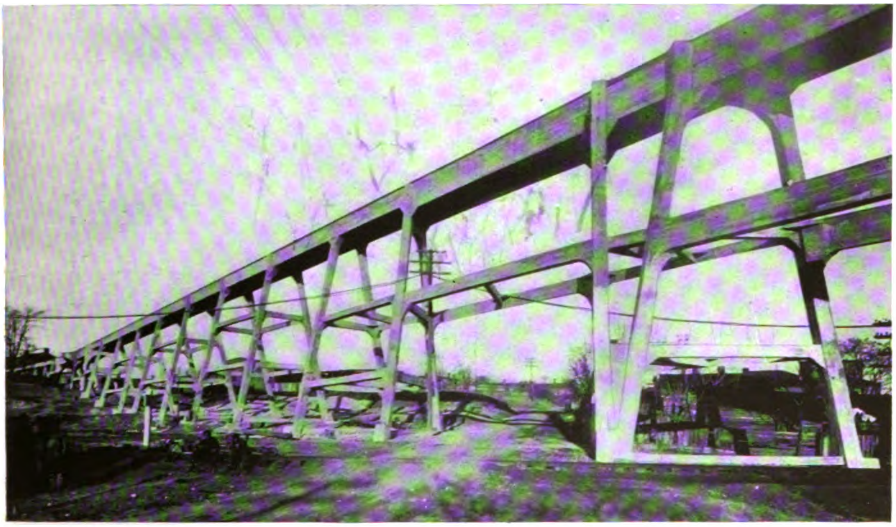


Reinforced Concrete Viaduct for the Richmond and Chesapeake Railway, Richmond, U.S.A.

With roadway and copings on a level grade, the balancing of unequal spans was accomplished by increasing the fill over crown and decreasing the rise for the shorter spans. Since the crown thickness for fixed loading is approximately proportional to the horizontal thrust, balanced thrusts at piers demand uniform crown thickness in all spans for symmetrical arches. The crown thickness in the crown formula is therefore assumed constant, and the rise and fill determined for the various spans under fixed loading only. Because of the magnitude of this structure the loading was assumed at 200 tons on two trucks, and crown thickness and piers increased at purchasers' request, otherwise empirical method applies.

(Section of completed viaduct crossing main thoroughfare.)





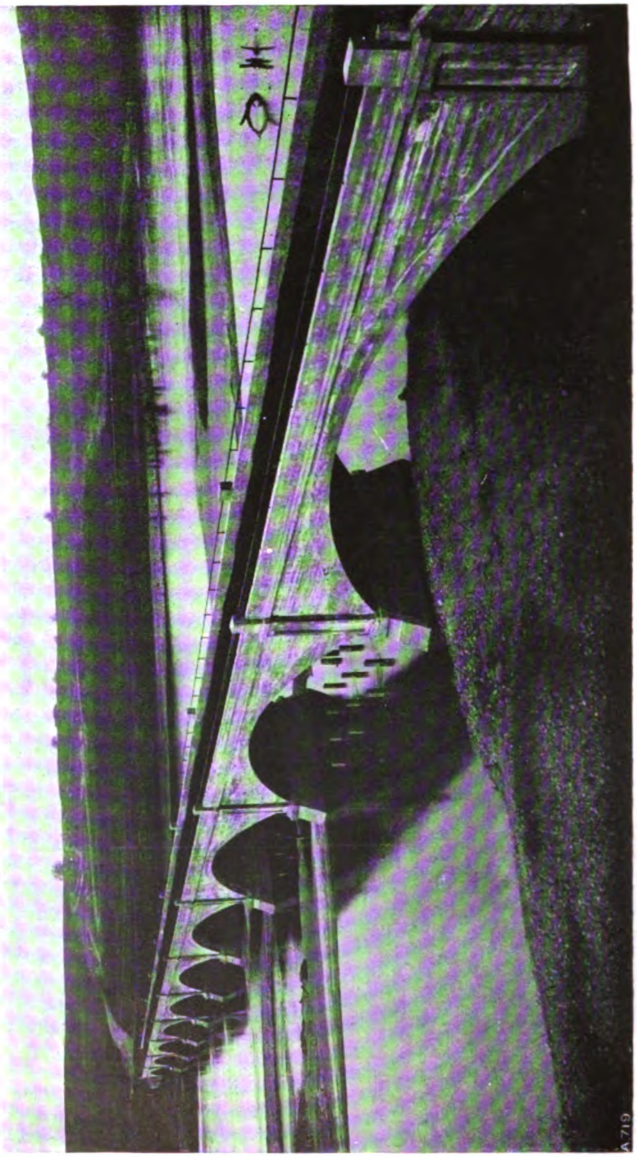
Reinforced Concrete Viaduct for the Richmond and Chesapeake Railway.
(Finished section, showing concrete frame supports.)

The contents of the bridge are about 9,000 cu. yds. of concrete and 125 tons of steel. Commenced May, 1907, completed January, 1908.

Viaduct for the Richmond and Chesapeake Railway.—This bridge was constructed by the Trussed Concrete Steel Co., Ltd., of Detroit.

The viaduct consists of a series of interbraced and battered bents, varying from 14 ft. to 70 ft. in height, and carrying the track on two parallel girders, varying in span from 23·5 to 67·4 ft. At some points it is 70 ft. above street level.

Special points of interest are the large girder beams and the use of concrete beams as struts. The columns have no distinctive features. The connection at the bottom is made by a tenon fitting into a mortise left in the footing together with dowel rods running some 4 ft. up into the column. The struts are square beams, designed



The Pollasky Bridge, California.
(Reinforced Concrete Bridge over the San Joaquin River.)

as columns, rigidly connected with brackets to the bents. The girder beams vary in span from 23 ft. 6 in., with a section of 12 by 30 in. to a span of 67 ft. 4 in. and a section 22 by 60in. The track consists of 80 lb. rails, spiked to 8 by 8 in. cross ties, which are bolted to sleepers, 6 by 12 in. on tangents, and on the inner tracks of curves, and 12 in. by 12 in. on the outer curves, thus giving an outer elevation of 6 in.

These sleepers are embedded in the concrete girders. Bolts were set in the concrete, with every sixth bolt projecting through the tie and sleeper, and the others through the sleeper only. To facilitate the setting of sleepers and ties, and to prevent the bolts rusting off, 2-in. holes were bored and afterwards filled with cement mortar. Cross ties are dapped 1½ in. over sleepers, and are placed 12 in. on centres. Every fifth cross tie is 4 ft. longer than the others, and to it is nailed planking, which serves as a sidewalk 40 in. wide. This arrangement of the roadbed was primarily designed to provide a cushion against the transmission of vibration and impact into the structure, and has proved satisfactory.

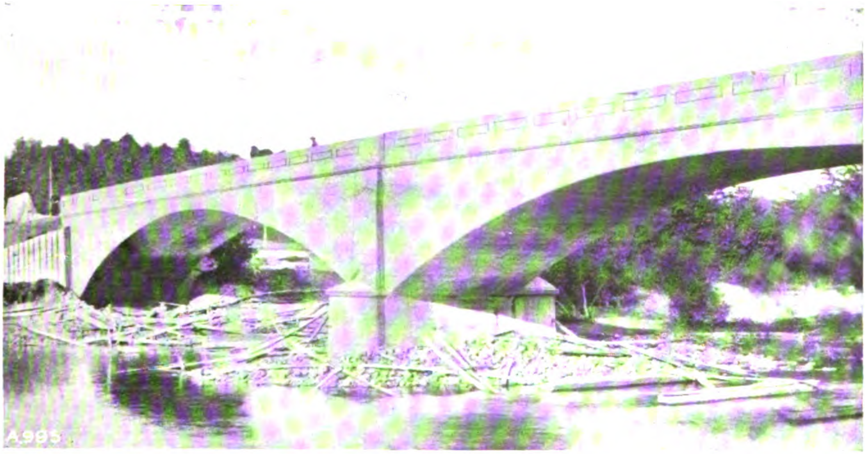
Expansion joints have been provided where the short girders rest on the brackets, at distances from about 125 ft. at the low bents to about 200 ft. at the high ones.

The Pollasky Bridge, California. –This bridge was designed by Mr. John B. Leonard, and constructed by the Pacific Construction Company of San Francisco. In our issue, Vol. I., No. 6, we presented two photographs of the bridge during construction, and we now show a photograph of the finished structure.

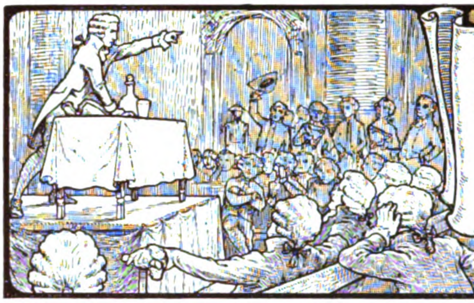
This bridge across the San Joaquin River, in California, comprises ten 75 ft. arch spans, and at each end the abutments are carried back as wing walls, making the total length 780 ft., while the width inside the spandrel walls is 18 ft. The arches, piers and abutments form one monolithic mass, but expansion joints are provided for the spandrel walls over each pier.

The reinforcement consists exclusively of Patent Indented Bars. Six sets of centering were used for the bridge, being moved from span to span as work progressed.

Red Bridge, Huntingdon, Indiana.—This bridge was constructed by the National Bridge Co., with two spans of 105 ft. each and a rise of 14 ft. The height of opening is 19 ft., and the roadway 16 ft. The crown is 21 in. The arch rods are ¾ in. spaced 12 in., and the copings are cambered 18 in. The railings are monolithic, 6in. by 3 ft. high. The bridge was designed for a 20-ton road roller, or 20 tons per sq. ft. The foundations are on hard pan, with south abutment resting against the stone pier of a former wooden bridge.



RED BRIDGE, HUNTINGDON, INDIANA.
(Erected for the Board of Commissioners of Huntingdon)



THE POSITION OF REINFORCED CONCRETE IN GERMANY AND AUSTRIA.

Extracts from Papers presented at the Vienna Congress of Architects, 1908.

By LUDWIG ZÖLLNER (Munich) and PROFESSOR v. EMPERGER (Vienna).

(Free Translation from the German.)

Two papers of importance dealing with the position of reinforced concrete in Germany and Austria were presented at the Vienna Congress of Architects, and of these we are publishing extracts.—ED.

GERMANY.

In Germany the execution of important works in reinforced concrete already goes back many years.

Although many objections were raised against this method of combining two of our best building materials, steel and concrete, it was even at the outset very generally recognised that the new form of construction must lead to a complete revolution in building methods.

But it was hardly expected that the change would proceed so quickly as the numerous and extensive structures of the last few years have shown it to do, since it was by no means easy at first to persuade building owners, architects and engineers to employ the comparatively strange new material in place of the older methods.

Co-operation of the Technical Interests concerned.

The Union of German Architectural and Engineering Associations rendered an important service to the progress of reinforced concrete in Germany when it instructed a committee in 1903:

1.—To prepare, in conjunction with the German Concrete Association, preliminary rules for the preparation, execution and testing of reinforced concrete structures;

2.—To present a memorial to the Imperial Chancellor, praying that official rules for the whole German Empire should be drawn up, based on scientific and technical experiments.

The rules mentioned in (1) appeared in August, 1904, the Prussian regulations for the use of reinforced concrete in buildings having already appeared on April 16th, 1904.

The memorial to the Chancellor (April 24th, 1905), and the great interest in the new system shown by the Prussian Government, led to the establishment by the Prussian Ministry of Public Works of a committee, known as the German Commission on Reinforced Concrete, to which the representatives of the German State Departments, the larger German States, the Material Testing Stations, the German Concrete Association, the Association of German Portland Cement Manufacturers, the Union of German Architectural and Engineering Associations, the Association of German Engineers, and the Association of German Ironmasters belong.

The principal task of this Commission is to prepare, on the basis of extensive scientific experiments, regulations for reinforced concrete work over all Germany, in order to prevent the recurrence of the numerous accidents which have occurred in the construction of reinforced concrete works, especially floors, by unskilful persons. For such experiments the sum of £22,500 has been provided for the years 1907-1911 by the German and Prussian Governments, and the Concrete, Cement, Engineers', and Ironmasters' Associations. The first series of experiments comprise the adhesion of concrete to steel, taking into account the influence of the amount of water used in mixing, the nature of the surface of the steel, the best mode of provision against shear, the protection of columns, the behaviour of reinforced concrete in peat and sea-water, the action of electricity, the fireproof character of reinforced concrete, etc.

Research Work in Germany.

These experiments are being carried out in the German experimental stations, attention being given to the results gained from investigations in previous years. The completion of the work of the Commission will be a landmark in the history of concrete and reinforced concrete in Germany.

The confidence which has been placed in reinforced concrete is best illustrated by the large number of works, often of great importance, already executed. Whilst formerly projects of reinforced concrete construction were submitted almost exclusively by specialist firms in competition with older methods of building, we have now fortunately advanced so far that in many buildings, for which reinforced concrete seems suitable, this material is adopted from the first in the specification. As a striking example may be mentioned the German Museum in Munich, about to be erected with the co-operation of the whole German Empire, it being intended that this home of the masterpieces of science and industry should itself be a masterpiece of modern building construction.

Practical Work in Germany.

An account of the numerous buildings erected would lead us much too far, and it would be difficult to fix a limit. We can only remark generally that warehouses of up to eight storeys and carrying heavy loads have been built, mainly at the wharves of large rivers. Floors, beams, columns and roofs have been applied in most kinds of industrial and commercial buildings, such as shops in the large towns, offices, mills, breweries with malt and grain silos, ironworks with large and heavy ore bins, cooling towers, cement works, and factories for all branches of the metal, paper, and leather industries. Of public buildings, theatres (especially for construction of tiers), halls, baths, and hospitals may be mentioned, the latter especially on account of the hygienic advantages.

Examples of Reinforced Concrete in Germany.

Of recent public and official buildings distinguished by the way in which reinforced concrete is employed, one of the most important is the new Royal Anatomy Building in Munich, in which the mode of construction is most happily expressed in the architecture, as well as the Exhibition galleries in Münich, the halls containing the platforms in the Nuremberg Railway Station, and the extensive buildings of the new city slaughterhouses in Dresden. Even in Berlin, where the development of reinforced concrete was greatly hindered by official restrictions, important buildings have been thus constructed since the recent removal of those restrictions, among them an extensive Parcel Post Office.

Of bridges, the Grünwald Bridge near Münich, with its two arches, each 70 m. (228 ft.) span, is up to the present the largest reinforced concrete bridge in Germany. The railway bridge for the Berlin Circle Railway, with a single very flat three-hinged arch of 40 m. (131 ft.), is a notable success for reinforced concrete, since it was long before it was thought well to use long spans thus constructed for railway bridges.

Small wooden bridges are often replaced by flat T-beams, as the absence of thrust in this form of construction often allows the existing stone piers to be used. The longest flat bridge of the kind in Germany is at Dresden, and has a clear span of 22·6 m. (74 ft.).

Lastly, there are the applications below ground in foundations, wells, piles, retaining walls, sewers and pipes, and docks.

Architectural Treatment of Reinforced Concrete.

As regards the æsthetic side of the question, it has sometimes been complained that reinforced concrete, on account of its too slender appearance, does not lend itself well to architectonic requirements. But the contrary is evident in a large number of buildings. For instance, the bridge over the Isar at Grünwald, in spite of the absence of decorative accessories, is artistically pleasing, the effect being due entirely to the lines of the design and material.

Since in a reinforced concrete building the structural character is as evident as in a masonry building, an erection of this type, if on correct statical principles, cannot be inartistic, and its light appearance should fulfil the highest architectonic requirements. Since antique stone architecture, which, like reinforced concrete, employed mainly massive horizontal beams and massive columns, developed such noble forms, it is certainly possible for the new construction, with its far greater plasticity, to invent beautiful forms, if only the designing architect, in making his first sketches, will always bear in mind the structural conditions of his material.

The new Anatomy Building in Münich is a decisive example, since not only the whole internal construction, panelled floors, vaulting, domes, etc., are of reinforced concrete, but the whole external surface of the dome and central building is of the same material and proclaims itself as such. *(See illustrated article in this issue.)*

Thus even in this respect all the old prejudices vanish, and there is no doubt that the new mode of building must find ever wider and wider application.

AUSTRIA.

Extracts from a Summary by Professor von Emperger (Vienna).

The present time, then, seems to be a landmark, starting from which reinforced concrete construction, now the common property of the technical world, will assume the place alongside of the older building methods which is its right on economic grounds. Patents and trade secrets, necessary as they are as stimuli in the opening up of new paths, continually lose their value in this department as in others, they even become a hindrance to the treatment of general problems, and it is a sign of maturity that reinforced concrete construction is now outgrowing that stage.

Co-operation of Technical Interests Concerned.

In Austria political conditions are not very favourable to the encouragement of technical matters, and even the attempts of industry to help itself are greatly hampered by the fact that our conflict of nationalities reaches even so far. Fortunately this has not been the case in our subject. Reinforced concrete has been in the hands of a separate industry, its recognised centre being Vienna, in and from which a number of large and important firms have arisen. Although these have only recently formed an organisation, the "Austrian Concrete Trade Association," yet from the beginning a lively interest and technical co-operation have existed, which have largely compensated for the absence of official support.

Research Work in Austria.

As an example I may mention the unique experiments of the "Austrian Institution of Civil Engineers and Architects" in the years 1891 to 1893, which were due almost exclusively to private enterprise. It will be remembered that these were the first large-scale experiments with reinforced concrete in the world. After this extraordinary effort we have to record a long pause, which still continues, since it was only last year that the last-named Institution elected a committee for reinforced concrete, which already has funds amounting to about £2,500, and has undertaken experiments on the subject. Whatever has been done in the interval has been of a purely private character, if we except the loading tests which are regularly prescribed by the Vienna Building Authority before the authorisation of new systems.

But I must not omit a whole series of experiments out of false modesty because they were carried out by myself. These are experiments with columns and beams. For the first, the material was placed at my disposal in 1901 by the then existing three Vienna reinforced concrete firms, E. Ast & Co., Pittel & Brausewetter, and G. A. Wayss & Co. The investigation has only just been completed, and is laid before this Congress for judgment. I have recently supplemented it by a series of steel columns encased in concrete. An important result of these experiments is that I have succeeded in showing that the breaking load of a reinforced concrete column or of a steel column cased in concrete may be estimated by determining the breaking load of the steel column and increasing it by the compressive breaking load of the concrete section surrounding the steel, quite independently of the ratio of elasticity of the two materials.

In this way it is possible to increase the strength of a steel column by casing in concrete so that the cost is reduced to one-third of that of steel alone.

My experiments with beams have been published in the *Forscher-arbeiten über Eisenbeton*, Parts 3 and 5; and whilst the experiments mentioned above are probably the largest series ever undertaken with columns of this kind, the experiments with beams, which I carried through entirely with private means, were necessarily of a much more modest character. I was nevertheless able with such small means to reach most of the conclusions later arrived at by C. von Bach in his extensive and exhaustive experiments, such as the influence of bent-up ends of reinforcing rods, perpendicular and oblique stirrups, the displacement of steel in concrete, etc.

The remaining experiments are all those made by firms for their own purposes. I must except the investigations of Messrs. Ed. Ast & Co. with Hennebique beams, which have been made public, and a later series of scientific experiments undertaken by Prof. Tetmajer. These yet await completion, and have sustained an irreparable interruption by the death of that investigator. Finally, there are several experiments, not yet published, undertaken by Prof. Hanisch on behalf of Messrs. Rella & Nephew.

This being all that we have to record in the department of experiment, the survey of practical achievements is all the more gratifying, especially when it is remembered that the field of operation in Austria must be considered small in comparison with other countries.

Practical Work in Austria.

As far back as 1890 Wayss constructed his first reinforced concrete beam in his Vienna workshops, but it was only later that he became prominent in this mode of construction, and it is especially to the impulse given by Hennebique at the Paris Exhibition of 1900 that we, like the rest of the world, owe the possibility of applying it in practice on the large scale. Only eight years have elapsed since then, but the activity of the firms concerned has increased rapidly, the area of reinforced concrete floors executed in 1900, for instance, being 53,000 sq. metres, and in 1907 632,000 sq. metres.

At first only two firms were concerned, to-day nine firms have to be included, and the work accomplished has increased tenfold, although the present total area of over 1½ million sq. metres, of which the lion's share falls to Messrs. Ed. Ast & Co., does not represent the whole area actually constructed. There are now, besides these large central firms, quite a number of provincial firms engaged in the work, so that the figure given should probably be increased by one-half.

We have now reached such a position that in all large buildings in Vienna no form of floor construction but reinforced concrete comes into question, and all that has to be decided is which of the many different forms is the most suitable, whereby I must not be understood as giving a narrow interpretation to the term "reinforced concrete." [An exhibition of the principal works of this kind in Austria was arranged for the Congress.]

Examples of Reinforced Concrete in Austria.

I may mention a few examples near to the centre of the city :—The house at the corner of the Corn Market and Magdalenstrasse (architect, Stephan), the Zacherl Building in the Brandstätte (architect, Plecnik), the Police Prison (architect, Hofr. von Förster), and the Post Office Savings Bank (architect, Otto Wagner), these four built by Ed. Ast & Co. Near them are the Chamber of Commerce and Industry (architect, L. Baumann) and the business premises at the corner of the Kartnerstrasse and Himmelpfortgasse (architect, Hofmeier), and also the Gerngross Building in the Mariahilferstrasse (architects, Fellner & Helmer), built by G. Wayss & Co. The new Courts, the Jacoberhof (architect, Förster), and the Military Court (architects, Snietivy & Ott), erected by Rella & Nephew, and lastly the Vienna Burg Theatre (architects, F. von Krauss & J. Tölk), erected by Diss & Co., are further examples of activity in Vienna.

The Congress will also see extensive applications in the hospitals. Ready-made components on the Siegwart, Visintini, Herbst, and other systems have also been introduced, although only to a small extent in comparison with the total area of floors. Factory construction is almost entirely dominated by reinforced concrete, the short time necessary for execution being here a striking advantage. In fact nearly two-thirds of the total floor area mentioned is accounted for by factories and warehouses.

CONCRETE-MAKING MACHINERY.

PART I.

By DR. JOHN S. OWENS,
A.M.Inst.C.E., F.R.G.S.

The appliances available for concrete-making or mixing are not fully known, and we are thus publishing two articles dealing with this important subject.—ED.

THE process of making concrete consists essentially of two parts: measuring the ingredients and the subsequent mixing of them together. I propose, therefore, to consider each part separately in the first instance, and endeavour to state clearly the conditions which experience has shown a reliable machine must fulfil, to either measure or mix properly. I will then go on to a review of the methods adopted in the most modern machines.

First, then, let us look at the materials with which we have to deal, and consider how they lend themselves to the processes involved in concrete making We find that, regarded from this point of view, they have entirely different characteristics.

Concrete, as is well known, consists of a mixture of :—

(1) Coarse gravel, broken stone, clinker, or similar hard, coarse material. (2) Sand. (3) Cement. (4) Water.

The ordinary method of gauging these materials for hand-mixed concrete is by means of boxes or vessels of known capacity, into which they are filled. This is probably the only method which is applicable to all four. When mechanical measuring or mixing is attempted certain peculiarities of each material soon show themselves. Broken stone or ballast will not run freely from a hopper, and has a powerful abrading action on moving parts in contact with it. Sand, unless dry, will not run freely from an opening, and its behaviour is very much affected by variations in the amount of moisture present. When quite dry and clean it will run from a small opening almost like water, but when the interstices are filled with water it becomes stiff, and refuses to flow, or to slide from an inclined plane, unless the surface be nearly vertical. In my experience the ordinary damp sand used for concrete will not satisfactorily leave the inclined plate of a hopper unless it is at nearly 30 deg. to the vertical.

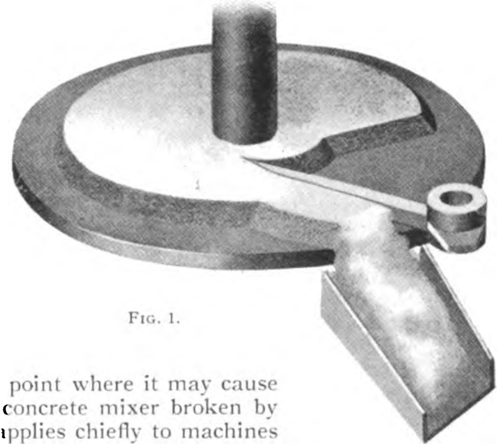


FIG. 1.

Cement has a way of clogging up its measuring mechanism, and, unless thoroughly cleared out when work is done each day, will probably set in the corners and on the parts of the machine which, for accurate measurement, should be scrupulously clean.

So much for their behaviour during measurement; when mixing begins the individual peculiarities of the different materials again show themselves. Coarse pieces of stone are often found to jam in awkward positions; sometimes a stone will stick at a point where it may cause injury to the machine. I have seen a concrete mixer broken by this cause several times. This danger applies chiefly to machines in which revolving arms are forced through the mass to be mixed. When mixing is done by means of a revolving box or drum in which the materials are tossed about, this danger is practically absent. Again, when the mixer has arms revolving through the concrete, I have often seen stones become fixed or balanced on the leading edge of these arms, and by having to be forced through the mass of concrete greatly increase the power required to drive the machine. Again, when the mixed concrete is thrown in a heap there is a well-known tendency for the large particles to roll down the sides and collect in a fringe round the margin of the heap.

Sand and cement, especially if there is not much water present, tend to clog the machine, and refuse to work freely; the coarse matter and water, on the other hand, tend to clean the mixing parts. It may, therefore, be said that as the proportion of sand and cement to broken stone or ballast increases, so does the difficulty of thorough mixing increase. This is felt on the works in the greater time required for mixing concrete with a very fine aggregate as compared with that required when the aggregate is coarser, and the proportion of stone larger.

It will be seen from this that it is a great advantage in a mixer to be able to vary the time that the concrete is exposed to the mixing mechanism, in accordance with the requirements of the material used.

We find that the increasing use of concrete reinforced with steel in some form has introduced a new factor in connection with concrete-making. In making ordinary concrete care is not always taken to make sure of having enough sand and cement in the mixture to entirely fill the voids between the larger particles of stone; this results in a porous concrete, which permits leakage of water through its interstices. Hence it has been usual, where water-tightness has been an object, to specify some form of rendering to the surface of the concrete, to prevent leakage. Except for this leakage no great harm has resulted from porosity in the case of land works; sea works are, however, on a different plane, and call for a non-porous concrete, owing to the chemical action of the sea water on the cement.

In preparing concrete to surround steel reinforcements it is absolutely essential that all these voids should be filled, otherwise rusting of the steel will probably result, and injury to the work. Hence we see that, although for ordinary concrete the exact proportion of sand to stone is not always of vital importance, we have to treat reinforced concrete differently, and make quite sure that the amount of sand and cement will be sufficient to make, with the coarser particles, a solid non-porous mass.

Passing on now to the various methods which may be employed for measuring the materials for concrete, we find that certain conditions must be fulfilled to ensure success: First of all, the mechanism must perform its duties with accuracy; it must not be complicated or delicate in its parts; it must not wear rapidly, and so require constant repairs; cement dust must not clog it, nor interfere with it in fulfilling its functions properly; the apparatus must be capable of working efficiently with either damp or dry materials. The keynote of the whole thing should, therefore, be simplicity and ease of access for cleaning. Any method of mechanical measurement should, other things being equal, be more economical than hand labour. It is also of importance that, not only should the machine measure the proportions accurately, but it should be possible for the clerk of works to easily check these proportions, and ascertain that they are as specified; this is a point often overlooked in designing continuous measuring devices.

In most modern machines provision is made for gauging the stone, sand, and water only; the cement gauging being done by hand. This greatly simplifies the problem, for when all the materials are mechanically measured it is not easy to provide for varying their relative proportions; whereas when the cement is gauged by hand the quantity of this, which is the chief variable ingredient, can be altered at will. Measuring the cement in this way is probably as economical for ordinary work as mechanical measurement; it takes very little more labour than the filling of the hopper of an automatic apparatus.

Concrete-making machines are usually divided into two classes: "Continuous" mixers, which deliver a continuous stream of concrete; and "Batch" mixers, which receive and mix a single charge, and cannot receive further materials until that charge or batch has been delivered.

The former type requires a constant and steady feed, and, therefore, does not lend itself so well to accurate mechanical measurement. There are, however, machines of this type on the market which I shall describe further on, and which seem to act efficiently. The methods of measuring which are applicable to continuous mixers are, therefore, limited. The worm or screw conveyor may be mentioned; it has been used with success for gauging the cement, but has several drawbacks. It is not applicable to ballast or sand measurement, owing to the great wear and tear. To vary the proportion of cement used the speed of the worm or the depth of opening of a sliding gate may be altered. It is obvious that with this method, although the supply may be fairly steady, it would be difficult to make sure that the exact proportions required were being supplied; only by periodical tests of the mixed concrete could this be assured.

The ordinary chain and bucket elevator has been used for both measuring and elevating the sand and ballast for a continuous mixer, and, like the worm, works fairly well; it is, however, open to somewhat similar objections, and cannot be regarded as an accurate measuring device. Sand, when damp, clings to the sides and bottoms of vessels used to measure it; and when a large number of small vessels is used, as in a bucket elevator, the amount of error in the quantities delivered may be very great. The error due to sand or cement clinging to the sides is very much greater in small than in large vessels, since the capacity of a vessel varies as the cube of its side, whereas the internal surface, to which the materials cling, varies as the square of the side. The larger the vessel the smaller will be the percentage of error due to this cause. In my experience this is an important factor, and one which causes a variation of unknown amount in the quality of the concrete produced.

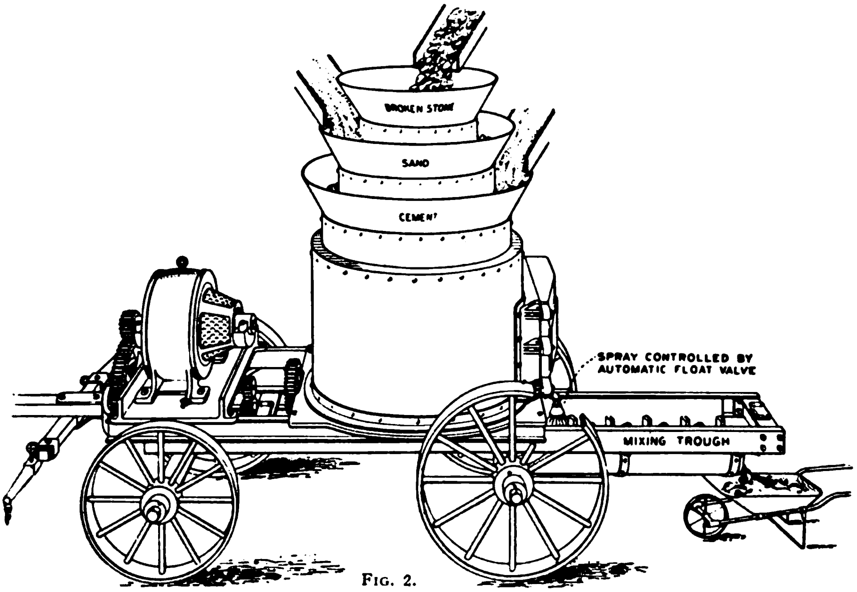


Fig. 2.

Again, since the filling of the buckets is done by the machine, the amount contained by each is not constant; it is not as if the surface of the material in each was struck off flat, it may be piled up in some and hollow in others. The error due to this cause is greatly affected by the amount of moisture present in the sand or ballast; since the buckets will carry up larger loads of damp than of dry material. This method of measuring cannot, therefore, be looked upon with much favour.

Another continuous method adopted is the revolving table. In this a circular table provided with pockets is made to revolve under a spout, from which the materials to be gauged are delivered to the pockets. At a certain point in the revolution of the table a valve or door is opened in the bottom of each pocket, and the contents are thus shot into a hopper under the table. The Le Mesurier mixer, designed for the Birkenhead Dock, utilised this method. A belt elevator was provided passing under the table; the latter had hoppers of about 2 cub. ft. capacity arranged round its periphery. The hoppers were filled direct from a stone breaker or by hand, and on reaching a point over the end of the elevator they discharged their contents upon the belt. The Cary-Latham mixer also used a somewhat similar means of measuring, although in some of these machines a worm was used for the cement and a chain and bucket elevator to measure the sand and ballast.

A very interesting type of continuous gauging device has been described by Mr. E. N. Trump in a paper before the American Society of Engineers. This also utilises a revolving table, but instead of having a series of pockets round its edge it is quite plain, and is fixed beneath the end of a cylindrical hopper. This cylinder has its axis vertical, and its end a certain distance above the table, which acts on the following principle. If over a table such as this a thin layer of material is spread, see *Fig.* 1, and projecting into which from the edge is a stationary knife or diverting blade, the depth of "cut" of which can be altered; then each revolution of the table causes a measured quantity to be diverted over its edge by the knife, and the amount so diverted can be altered by varying the depth to which the knife projects over the table.

In the actual machine the cylinder is kept full, and the effect is similar to that described when a thin layer only is placed on the table; since the bottom edge of the cylinder regulates the thickness of the layer which is removed. The cylindrical hopper is somewhat smaller in diameter than the table, and is supported by arms from a central spindle, revolving with the table.

The factors which influence the amount of material diverted, or measured, in a given time are :—(1) The distance between the bottom of the storage cylinder and the table. (2) The width of the knife. (3) The speed of rotation. (4) The depth of cut of the knife. Nos. (3) and (4) are adjustable.

When it is desired to proportion two or more materials, a combination of two or more cylinders and tables is used. Such a machine is shown in *Fig.* 2. The tables are set one above another, and the cylinders arranged concentrically on the same shaft. Each table and cylinder has its own knife. When making concrete the discharge is so arranged that the material from the top table falls into the stream from the next below, and the combined stream thus formed falls into that from the lowest table; hence a preliminary rough mixing of the dry ingredients takes place.

The inventor states that this machine acts equally well whether measuring fine cement or rocks up to 6-in. cube; he says that in the case of a 12-ft. table feeding rocks 6-in. cube, the variation of delivery for a single revolution showed less than 2·5 per cent., and for ten revolutions less than 0·5 per cent. of the quantities delivered. This machine measured about 6,000 lb. per revolution.

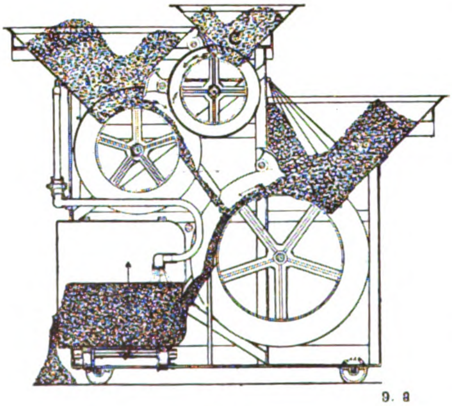


FIG. 3.

In his handbook of machinery Mr. Appleby thus describes a method of gauging used with a continuous mixer :—

> It consists of a machine . . . with two pairs of bins fixed over the mixer hopper, and drop doors opening into it, with appliances for controlling the deliveries. The larger bin of each pair contains the broken stone, shingle, etc., and sand, and is generally one cubic yard capacity; the other is of the size required for the specified proportion of cement. These bins being side by side, and each pair opening simultaneously (whilst the others are being refilled), it follows that the contents become distributed before they enter the mixing vessel. The time occupied in filling the bins is rather less than is required for complete mixture . . . so that with the two pairs of bins the operation can be continuous if so desired.

A method adopted in one American machine consists in fixing a series of hoppers side by side over a single revolving roller. These are provided with gates where in contact with the roller, and the revolution of this carries away a definite quantity of material. The amount delivered per revolution depends on the size of the opening at the base of each hopper, and this is capable of adjustment.

A somewhat similar type of machine is illustrated in *Fig.* 3. It is called the "Perfect" concrete mixer. In this machine each hopper is provided with its own roller, and these are so arranged that, as in the Trump machine, the streams from all the hoppers mingle before delivery to the mixer proper. With cement or fine sand there seems to be no reason why machines of this kind should not measure accurately; broken stone, however, is a more difficult thing to deal with. I have not been able to get any data as to the actual degree of accuracy obtained by this method.

All these different apparatus for gauging are useful only in conjunction with continuous mixers. We now go on to a consideration of the batch mixer and its gauging mechanism.

The actual measuring for this type of machine is always done in some kind of box or skip of known capacity. Sometimes this is simply the trolly or barrow in which the stuff is delivered to the machine, but usually some form of elevating and gauging skip has been employed.

The most generally used is a modified form of the bucket elevator, in which a single skip or bucket is made to ascend along a pair of guides, and deliver its contents by tilting into the mixing drum of the machine. *Fig.* 4 shows the Koppel machine, which is fitted with an elevator of this type. The skip is hauled up by a wire rope, which is wound on a drum actuated through a friction clutch; on arrival at the top the skip tips automatically, the friction clutch is thrown out of gear and a brake put on at the same time, which prevents it from falling back. When the skip is empty the brake is released by hand and it is lowered to the ground level, where it receives another charge. The height of this machine from the ground to the highest point is 15 ft. 3 in.

Other machines utilising this method are the "Fawcett," "Oehler," and "Smith," all used in this country.

In practice it has proved more satisfactory than any continuous measuring device. The quantity of material in each batch can be easily checked by the clerk of works, and deviations from the specified proportions detected, in a way which is impossible in continuous measuring machines. When there is plenty of head room this method is very suitable, but with the increase in the growth of reinforced concrete work a necessity has arisen for a machine of a low, compact type, capable of being worked between the floors of a building, and easily moved about. All devices which depend for their action on a skip hauled up by means of a wire rope require one or more pulleys higher than the skip at its highest position for the rope or ropes to work over; hence such machines are of considerable height, especially if mounted on road wheels. The Ransome-ver Mehr Machinery Co. are now placing on the market a machine, known as the Ransome batch mixer, which is fitted when desired with a tilting hopper for measuring and feeding. The highest point of their small reinforced concrete machine, although it is mounted on wheels, is only about 6 ft. above the ground level. This permits the whole apparatus to be moved into positions where the higher machines would not go.

Turning now to the actual mixing together of the ingredients after they are duly proportioned, the objects aimed at may be briefly stated as follows:—

(1) To distribute the various ingredients uniformly throughout the mass, so that each part of the resulting concrete shall contain exactly the proportions of stone, sand, cement, and water which have been specified. This may be termed the true test of thorough mixing.

(2) To completely coat each stone and particle of sand with the mixture of cement and water.

Speaking broadly, we desire to make a uniform mortar of cement and sand, and to fill all the interstices between the larger stones or pebbles with this mortar.

As pointed out before, we have two types of mixer—the continuous and the batch; and of recent years the trend of engineering opinion has been more and more in favour of the latter type. Some of the advantages of the "batch" over the "continuous" mixer have been referred to in describing measuring devices. It may be well, however, to summarise shortly here the relative merits and demerits of the two methods for ease of reference.

Taking first the continuous mixer:—

(1) It is of use chiefly where large quantities of concrete have to be delivered without intermission, as in the construction of sea and dock walls, foundations, etc. It is not suitable where only small quantities of concrete are required at irregular intervals, as in the case of block-making or reinforced concrete work.

(2) No method of continuous measuring is capable of the same accuracy, for all the materials concerned, as is measuring in boxes or skips.
(3) It is impossible for the engineer to exercise the necessary supervision over the proportions of the ingredients used.
(4) The amount of water in the concrete will depend somewhat on the rate of running of the machine, and cannot be accurately measured.
(5) The amount of mixing given to the concrete is not under the control of the engineer, but is fixed chiefly by the makers of the machine.
(6) The materials cannot be satisfactorily mixed together dry by the mixer before being wetted, although the attempt to do this has been made by delivering the water at some distance from the feed opening.
(7) All the materials must be fed into the mixer simultaneously, since there is a continuous movement from end to end, and if fed separately they would travel separately along the machine. This means that a preliminary dry mixing by hand is necessary before feeding into the machine.

Turning now to the batch mixer :—

(1) This is suitable for either a constant delivery of large quantities of concrete, or for small quantities at irregular intervals. It is, therefore, the only type fit for light work such as ferro-concrete.
(2) The exact proportions specified for the concrete can be assured with the greatest accuracy.
(3) The engineer can at any time check the proportions being used.
(4) The amount of water can be measured exactly.
(5) The amount of mixing given to the concrete is under the control of the engineer, and by specifying a definite number of revolutions of the drum, or a definite time, a perfect mixing can be assured.
(6) A preliminary dry mixing can be given, if desired, by the machine.
(7) The different materials may be fed to the mixing apparatus separately. There is therefore no necessity for hand mixing before feeding.

The ordinary form of continuous mixer is one in which the materials are fed into one end of a long revolving cylinder, or a trough containing a revolving spindle with helically arranged arms or knives; the discharge takes place at the opposite end.

One of the first revolving cylinder machines was the Le Mesurier, used at the Birkenhead Docks. This was said to turn out 150 yds. of concrete per day at 4d. per yd. for mixing. The cylinder had projections or shelves on its internal surface.

Since then a great number of machines have been made on this principle. Various shapes have been used for the cross-section of the revolving box; in some it was square in section, as in one made by the Cockburn Barrow and Machine Co. of New York. In Weller's machine the section was somewhat like a cross, but in all these the principle was the same. The discharge was obtained by inclining the revolving cylinder or box downward at one end. In a continuous mixer made by Messrs. Mason Bros., Leicester, the place of the cylinder is taken by a hollow frustrum of a cone, the wide end being the discharge, and the axis horizontal. These machines do not call for special attention. The amount of mixing given to the concrete in any particular case depends on the inclination of the bottom surface of the mixing receptacle, and its length from feed to discharge.

The rate of revolution of the cylinder is limited by the fact that if a certain critical velocity be exceeded there is a tendency for the concrete to cling to the sides, and fail to mix or discharge. In practice, however, the velocity is never allowed to approach this point.

In the Cary-Latham continuous mixer, used at the Newhaven Harbour works, the materials, having been measured on revolving turntables, as before described, were delivered to a circular pan, from the centre of which radial arms carrying scrapers worked and levelled the materials, thus dry-mixing them to some extent. These arms pushed the mass forward to a delivery shoot where water was added, and the resulting concrete passed thence to a revolving cylinder inclined at an angle of 8° to the horizontal. This machine required a 20 h.p. engine, and was capable of delivering 100 tons of concrete in 20 minutes, at a cost for mixing of 35s.

A point of some importance in connection with these revolving cylinder machines is that unless the inclination of the cylinder can be adjusted, the rate of travel along the mixing cylinder will be different with different aggregates, and hence the amount of mixing will not be the same. An aggregate having a large proportion of sand calls for a greater inclination than one containing little sand.

The gravity mixer, in which concrete is mixed in the process of falling through a specially constructed shoot, is of the continuous type; it is most useful where large quantities of concrete are required below the ground level, as in deep foundations, etc.

The batch mixer consists of either a revolving box or drum, which receives the charge and tosses it about until mixed; or a fixed box or drum in which one or more spindles carrying arms revolve.

This type of machine requires an intermittent feed, and will be illustrated by the machines to be described in the next article.

Before going on to a description of the various machines, there is one point I would lay special stress upon. Nearly any mixer of the batch type will mix concrete perfectly, provided it is given sufficient time to do it in. The chief point to consider is not, therefore, will a particular machine mix properly, but rather will it, as compared with other machines, turn out more properly mixed concrete in a given time. The finished concrete represents several different operations. There is first the measuring or gauging, then the feeding into the mixing vessel; next comes the mixing proper; and finally, the discharge of the finished product. Time may be wasted on any one of these operations, and the machine which performs all four most expeditiously is, other things being equal, the best. The output over a period of, say, 10 hours is therefore the best guide as to the value of a mixer, provided always the concrete is efficiently mixed.

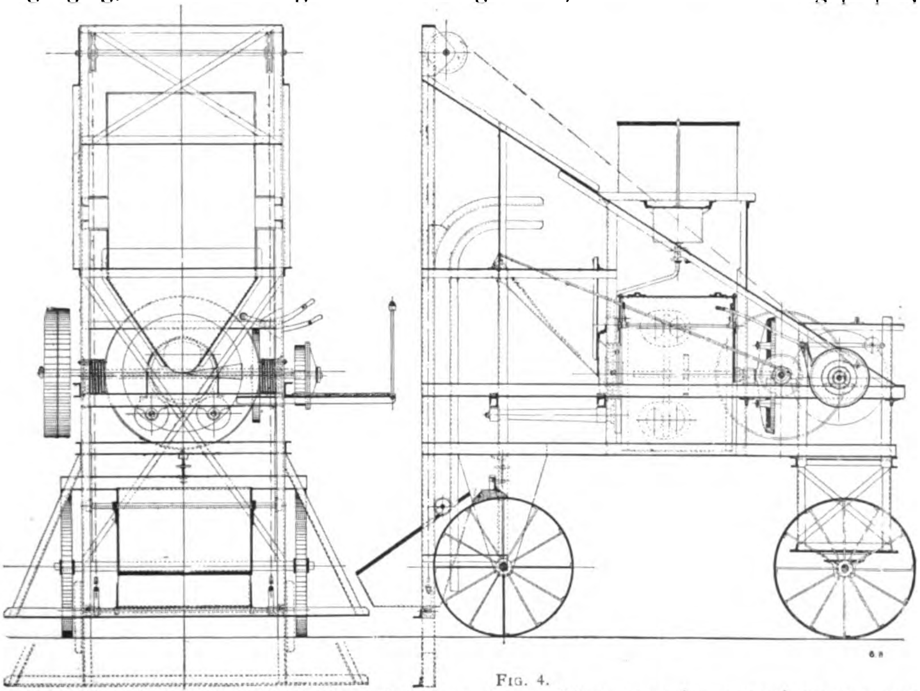


FIG. 4.

In a properly arranged machine the operation of measuring can usually be performed while the mixing of the previous batch is going on. Certainly a machine in which this is impossible cannot be considered as satisfactory. The usual cycle of events is therefore as follows:—

(1) Measuring a batch and filling it into the hopper of the machine; or filling an automatic measuring skip, the mixing of previous batch going on at same time. (2) Discharging. (3) Charging machine by opening a sliding door in the hopper, or by elevating and tilting the skip.

Having arrived at the greatest economy of time, the other points to be considered are: simplicity of construction; portability; compactness; ease of cleaning; power required to drive, and absence of fragile parts. The wearing parts should also be capable of easy renewal. It must be remembered that these machines often receive very rough treatment, and should be designed to resist such.

In the next article I will describe the various concrete-making machines, giving special reference to those which are most used in England.

(To be concluded.)

SPECIAL ARTICLES.

Under this heading we propose to present special contributions which reach us from time to time in connection with various subjects dealing directly and indirectly with concrete and reinforced concrete.—ED.

A FORMULA FOR COLUMNS.

By CHARLES F. MARSH, M.Inst.C.E., M.Am.Soc.C.E., M.Inst.M.E.

The following is a formula for high columns, walls or piles of reinforced concrete (when the height is greater than 20 times the diameter or least side), the columns being reinforced with longitudinal bars and cross-ties, but not hooped.

P=safe load calculated as a short column in pounds.

P_1=safe load on long column in pounds.

l=height of column in inches.

b=least side of a rectangular column in inches.

δ=diameter of a circular column in inches.

y=the several distances of the axes of the reinforcements (of small sectional area) from the axial plane in inches.

Note:—In a rectangular column this axial plane must be that parallel to the longer side.

In a circular column any axial plane may be taken.

C=ultimate resistance of the concrete in pounds.

r_c=the radius of gyration of the concrete assumed as being of total sectional area of the column.

r_s=the radius of "gyration of" the reinforcements.

n=number of reinforcing bars.

ω=the total area of the reinforcing bars in square inches.

bd=area of the column in inches.

c=safe compressive resistance of the concrete in lbs. per square inch.

k=a co-efficient.

Σ=sign of sumation.

E_s=modulus of elasticity of the reinforcing metal.

E_c=modulus of elasticity of the concrete.

$$m=\frac{E_s}{E_c}=15$$

Assuming c=400 and m=15

Then

$$P=400\left\{ bd+14\,\omega \right\} \quad . \quad . \quad . \quad [1]$$

Note:—The value of P for any sized column and any area of reinforcement may be obtained from the Diagram Fig. 363, page 339 of "Reinforced Concrete," by Marsh and Dunn.

$$P_1=\frac{P}{1+\frac{k^2\,C\,l^2}{\pi^2 E_c(r_c^2+r_s^2)}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [2]$$

If C is assumed as 2,400 lbs. per square inch and E_c is assumed as $2{\cdot}067+10^6$

Equation [2] becomes

$$P_1=\frac{P}{1+\frac{k^2\,l^2}{85+10^2\,(r_c^2+r_s^2)}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [3]$$

k^2 has the following values:

For columns fixed at the ends $k^2=\frac{1}{4}$.

For columns with one end rounded and the other fixed $k^2=\frac{1}{2}$.

For columns with one end fixed and the other free $k^2=4$.

The values of r^2_c are:—

For circular columns of diameter δ——$r^2_c=\frac{\delta^2}{16}$

For rectangular columns with least side b——$r^2_c=\frac{b^2}{12}$

The values of r^2_s will be (if all the reinforcements are of the same sectional area)

$$r^2_s=\frac{\Sigma y^2}{n}$$

TESTS WITH CONCRETE

AT HOME AND ABROAD.

We consider that the absence of reliable information as to the various tests carried out with concrete both at home and abroad has frequently led to misconceptions as to the qualities of this material, and we shall thus for the present accord considerable space to the presentation of authentic data that may be of service to those employing concrete in its various forms. The tests which will particularly call for our attention are those relating to strength, fire-resistance, and waterproofing.—ED.

RECENT TESTS IN THE UNITED STATES.

It is remarkable to observe that in all parts of the world questions relating to concrete and cement are having the attention of the technical professions and of scientists. The recent meeting of the American Society for Testing Materials is a case in point, for the principal papers and discussions of that important gathering were devoted to these matters.

The question of a standard specification for cement in the United States was under discussion; sands, and their relation to mortar and concrete was also a matter under discussion; a paper was presented on the Permeability Tests of Concrete, and on tests of concrete beams under oft-repeated loading; while the shearing values of stone and concrete; the formulæ for reinforced concrete beams; the influence of alkali water on concrete, were some of the subjects under review. The amount of useful information which will shortly be published by the American Society in connection with this gathering should certainly be considerable.

We present below a few short summarised particulars from the different papers so far as they relate to tests, for which summaries we are indebted to our contemporary *Cement Age*.

TESTS ON CONCRETE BEAMS UNDER OFT-REPEATED LOADING.

The above paper by Prof. H. C. Berry of the Engineering Department of the University of Pennsylvania, was among the most interesting read at the meeting. Not only had he evolved unique methods of testing beams, but made the announcement that he felt warranted in saying that a million loadings will not decrease the ultimate strength of a beam. How Prof. Berry arrived at this conclusion was described in his paper.

The paper consisted essentially of curves showing the plot of observations of deflection on 12 ft. span, unit deformation in the plane of the steel, and unit deformation in the concrete, 1 in. from the surface of the standard 8 in. by 11 in. beam.

He had six beams on the apparatus. Except one, when the motor failed for a time, they received many loadings; it had 69,000, four of the others had about 400,000, and one finished June 16th, had 1,140,000 applications.

The concrete was $1 : 1\frac{1}{2} : 4\frac{1}{2}$, Giant cement, except in one beam, when there was substituted Atlas, bar sand, and three-quarter, and smaller stone. Cylinders 8-in. diameter tested from about 1,600 to 2,100 lb. per sq. in. ult. str.

The reinforcement was varied. Three $\frac{3}{4}$ rounds, four $\frac{1}{2}$-in sq. rods, three $\frac{5}{8}$-in. sq. rods, three $\frac{3}{4}$-in. corrugated bars, and two $\frac{3}{4}$ Diamond Thatcher bars were used.

Readings were taken for increments of about 000 lbs. as the load was first applied, and then every day for the beam loaded and unloaded. The load was such as to cause a stress of from 14,000 to 18,000 lb. per sq. in. in the steel and from 700 to almost 950 in the concrete.

Exactly similar beams to three of them were made in the Lesley Cement Laboratory and used in class instruction, being tested by the students, but the beams were made by the same men that made the beams used on the apparatus, and as nearly alike as possible. These beams were tested at the age of six weeks. The other beams were placed on the apparatus at the age of four weeks, and given two weeks of repeated loadings, and then the loads increased to failure of the beam.

From a comparison of the tests Prof. Berry felt warranted in saying that 1,000,000 loadings does not decrease the ultimate strength of the beam, that total deflection at ultimate load is practically the same in both cases, that there is a quite evident "set" in the deflection readings, that hair cracks appear for a working load on the first or few applications, and that these hair cracks grow deeper for the same loading and approach the neutral axis of the beam for a great number of applications.

From an examination of the readings of the fiber extensometer from day to day, after they are plotted as curves it would seem that the deformation in the concrete increases with the number of applications, the width of the elastic area remains about constant for each beam, showing that the amount of the elasticity remains the same but that the "set" increases.

SHEARING VALUES OF STONE AND CONCRETE.

Henry H. Quimby, M.Am.Soc.C.E., Engineer of Bridges, Bureau of Surveys, Philadelphia, presented an interesting paper on this subject. Mr. Quimby began by saying that a very common failure of stone lintels is by shear-rupture in a slightly diagonal direction up from one of the points of support. It is not at all as uncommon as it should be for the seats of lintels and similarly loaded corners of brick work and concrete to shear off, although the line of rupture is at considerable angle with the direction of the stress.

With the advent of light concrete arches the question of the need for adequate resistance to shearing forces in an arch ring becomes pertinent.

After describing the result of tests with small model concrete arches the writer stated that it is very desirable that a designer should himself make the tests upon which he depends for his knowledge of the sustaining value of the material that he uses in important structures. The manner in which these tests should be made was indicated.

On the subject of arches Mr. Quimby said that a concrete arch, especially of the lightened spandrel type that is being more and more widely adopted for both railway and highway bridges, unless it is clumsily heavy, will have higher unit shearing stress in it than modern practice warrants—when it knows it—for plain concrete. In a large arch with open spandrels the weight of the ring itself is a large part of the total load, and therefore increase of section will be attended with such an increase of load that higher value cannot be thus obtained economically. The alternative is some species of reinforcement—not longitudinal, but transverse. If steel be used for the purpose it should be horizontal in the column and radial in the arch. Longitudinal steel reinforcement is of doubtful value for any but tensile stress, and transverse reinforcement partakes of the nature of hooping, and must therefore increase the compressive strength as well as the shearing resistance. The simple expedient of making a composite or hybrid material of concrete with embedded flat stone seems to meet these requirements of transverse reinforcement, and it has been adopted in a number of cases with very satisfactory results. It is a combination of stone masonry and concrete, and it has been found to combine also increased strength with reduced cost. The process consists of placing layers of concrete mixed wet and sinking into each layer as many flat stones of any convenient size as can be embedded properly. Without special effort to secure it a very satisfactory overlapping for bond is obtained by the mere law of chance in depositing, and skilled masons are not required. This construction produces the most compact possible class of masonry.

TESTS OF BOND IN REINFORCED CONCRETE BEAMS

This paper, a report of tests made on the bond between concrete and plain, round mild steel reinforcing bars, was presented by Mr. M. O. Withey, of Madison, Wis. These tests were made in the Materials Testing Laboratory at the University of Wisconsin during the spring and summer of 1907. The subject of bond between concrete and steel has led to many extensive series of tests. Most of these tests have been made by embedding a rod in the centre of a cylindrical block of concrete and pulling it out in such a way that the concrete around the rod was compressed. In general the results of such tests have neither given conclusive nor reliable data upon which working values for structural purposes can be based.

In order to approximate more closely the actual conditions in reinforced concrete beams a different form of bond specimen was used in the tests described, and the results compared with those obtained from the ordinary cylinder test. The larger proportion of the specimens were made and tested as thesis work by Messrs. A. B. Carey, S. L. Clark, and P. B. Johnson, of the class 1907, to whom due acknowledgment was made.

The methods of making the tests were described in detail, also the materials and their proportions. The author presented the following conclusions:—

1. The bond of 1 : 2 : 4 concrete to embedded steel increases with age at least up to six months. About 80 per cent. of its six months' bond strength is developed at 28 days.
2. Owing to the variation in results of the one-month tests, and the wide difference between laboratory experiments and practical working conditions, it does not seem as though the maximum bond of 1 : 2 : 4 concrete should be assumed greater than 200 or 250 lbs. per square inch in designing.
3. The method of making bond tests by pulling a rod from a concrete cylinder, as previously described, gives results which are of neither quantitative nor qualitative value. The results obtained are dependent largely upon compressive stress acting on the head of the cylinder.
4. The beam test for bond, on the other hand, approaches closely the actual conditions to which the bar and surrounding concrete are most often subjected, and gives values which are at least of qualitative value. Furthermore, values obtained by this method are in accord with the bond theory usually accepted as a basis in design.

These tests have been continued during the past year. The bond of both plain and deformed bars, when subjected to static and repeated loadings, has been investigated, and the results of all these tests will appear during the year in a University of Wisconsin bulletin.

NEW USES FOR CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented as to new uses to which concrete and reinforced concrete are put, with data as to experience obtained during the experimental stage of such new applications of these materials. The use of reinforced concrete as a substitute for timber in exposed positions is one of the questions of the moment. Railway sleepers, telegraph posts, fence posts, etc., of concrete are being tried. Similarly, efforts are at present being made to prove that reinforced concrete is an excellent substitute for brickwork, where structures of great height are required.—ED.

FACTORY CHIMNEYS OF CONCRETE BLOCKS.

WE have dealt in earlier issues with reinforced concrete chimneys, of which there are already a considerable number in this country, and we would now call attention to a system of constructing factory chimneys of concrete blocks reinforced by steel, which has certain novel features.

The reason why the reinforced concrete chimneys have perhaps not made the progress in this country that we should have expected is that contractors are rarely able to re-use the shuttering of one chimney on a second one, and thus the cost of the new shuttering discounts some of the economy effected in building reinforced concrete chimneys *per se*.

The combination of the concrete block with a steel reinforcement as recently practised on the Continent might, however, be said to overcome the difficulty in question, and we are presenting some particulars of a chimney of this type, which we believe is subject to certain proprietary or patent rights, controlled by the Belgian firm of Messrs. Léon Monnoyer, to whom we are indebted for the illustrations shown.

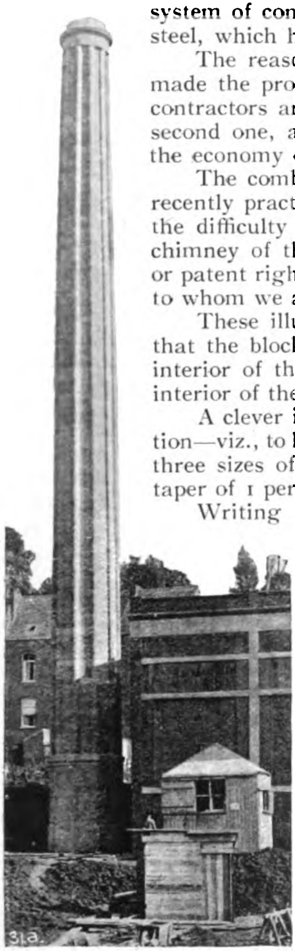
These illustrations practically explain themselves, but we would say that the blocks are placed in regular courses, and the men work in the interior of the chimney in gangs of four. The blocks are lifted up the interior of the chimney by an ordinary block and tackle hoist.

A clever idea in connection with this system has been put into operation—viz., to limit the number of the sizes of the blocks required; thus only three sizes of blocks are required for a chimney of some 150 ft. with a taper of 1 per cent.

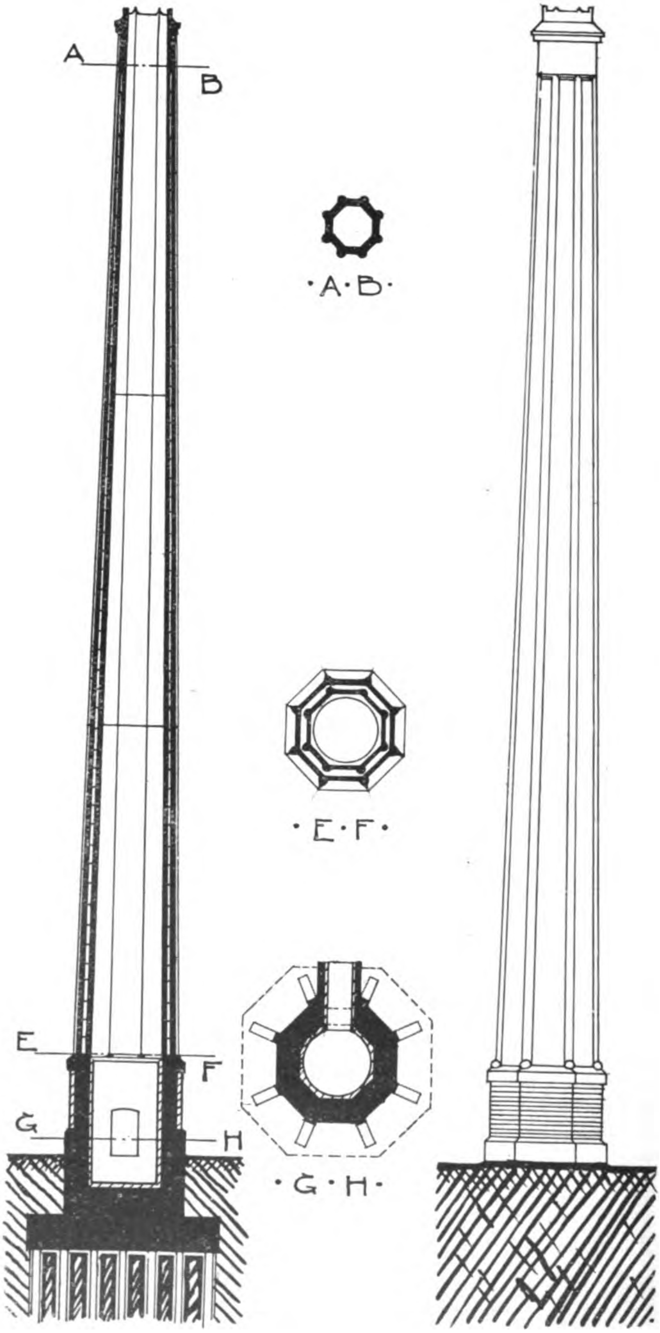
Writing upon the execution of this type of chimney, Mr. H. P. Kieffer, of Berlin, describes the work as being accomplished in the following manner:—

The concrete blocks are usually made at the chimney site, and their moulding is begun at the same time as, or shortly before, the excavation for the foundation. This allows ample time when piling is necessary, and in cases where this preliminary work is done first the blocks are in perfect condition for placing.

Upon the bottom moulding board along the full length of it in the centre is a triangular-shaped piece of wood, which is fastened with one of its faces flat to the moulding board. This strip of wood is about $\frac{3}{8}$ in. from the apex to the base of the triangle. When the block is moulded and turned, in which position it will finally be placed, there is a groove throughout its length of about $\frac{3}{8}$ in. deep. In this groove, connecting one block with the succeeding one in the same course, is placed a small steel rod which serves the double purpose of binding the blocks together as well as the vertical rods. These rods are tied to the vertical rods by a flat U-shaped piece of iron.



CONCRETE BLOCK CHIMNEY, 135 ft. high, for the Société Anonyme Les Ateliers Métallurgique de Nivelles. (3 ft. 10 in. dia. at top.)



28a.

CONCRETE BLOCK CHIMNEY.
(Plans, Section and Elevation.)

The height of the blocks is usually about 10 in., and the thickness varies from 6 in. for those at the bottom courses to about 3 in. at the top. Inside the block during the moulding three rods are placed at different elevations. This is done not so much for their final reinforcement as to enable them to be handled before and during construction.

Some remarkably rapid work has been done in constructing these chimneys. In one case the erection was completed, including a pile foundation, in less than a month. The concrete blocks, which comprise about 92 per cent. of the chimney, have in some cases been erected in ten working days.

REINFORCED CONCRETE LIGHTHOUSE ONE FATHOM BANK, STRAITS *of* MALACCA.

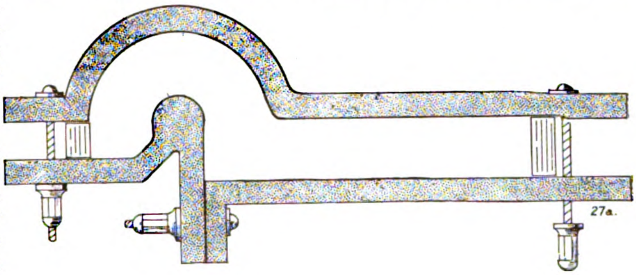
(*Extracted from an article by John Craig, in the "Engineering Review."*)

This reinforced concrete lighthouse is situated in the Straits of Malacca, about fifteen miles west of the coast and about half a mile west of the shallowest part of the bank, in three fathoms of water. The focal plane of the lighthouse is 92 ft. 6 in. above high-water level, and the light was exhibited for the first time on January 12th, 1908.

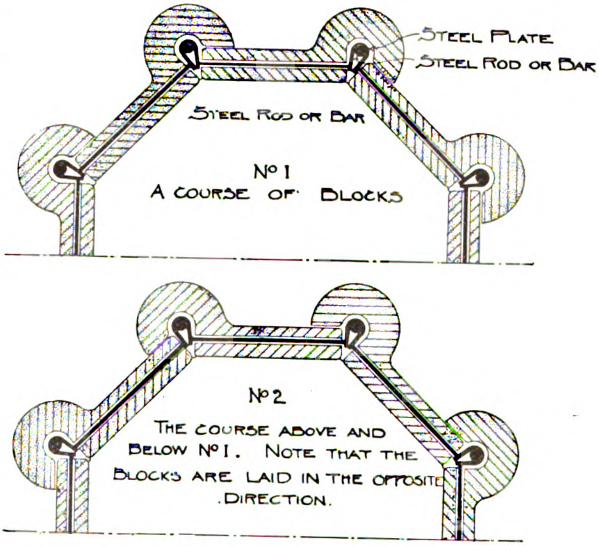
The structure was designed by Mr. O. P. Thomas, agent in Singapore for the Colonial Ferro-Concrete Syndicate, Ltd., and being favourably reported upon by the Hon. A. Murray, M.Inst.C.E., Colonial Engineer and Surveyor-General for the Straits Settlements, his tender for the work was accepted by the Legislative Council.

Owing to the very exposed position of the lighthouse the full severity of the weather during the monsoons was felt, which made all the work below high-water level anything but an easy task, the waves during the roughest weather, which happens at the beginning and end of the year, rising to a height of 8 ft. from trough to crest. The rise and fall of the tide is 14 ft. A temporary timber staging was thus required.

The reinforced concrete foundation piles, seventeen in number, were constructed on an island fifteen miles east from the site of the lighthouse, the concrete being gauged in the proportions of 2½ parts of granite metak broken to pass in any way through a ¾-in. cross-mesh sieve; 1½ parts of sand to 1 part of Portland cement; the piles were strengthened with steel rods 1¾ in. diameter, and laced with 3/16-in. steel wire every 6 inches. The piles were moulded hollow for the sake of lightness 50 ft. 6 in. long, eight being 18 in. sq. and nine 2 ft. sq. They were towed singly to the site on a raft constructed of twenty-six hogsheads, thirteen on each side of the pile, and made in four sections for convenience in releasing them therefrom. On arrival at the site the pile was floated under the staging, and from the pile-driver, which was placed in position for driving each pile, a chain sling was made fast to the head of the pile, the lashings removed from the rafts and the pile heaved slowly up, allowing the rafts to float out under the pile by the weight of the pile. After two sections of the raft had floated away, the remaining two sections were carried under the water, and when the pile reached an almost vertical position they came to the surface.



27a.


Steel Plate
Steel Rod or Bar
Steel Rod or Bar
No 1
A Course of Blocks
No 2
The course above and below No 1. Note that the blocks are laid in the opposite direction.

26a

Concrete Block Chimney (Details).

The piles were kept in their true position by two sets of guides made of timber 10 in. by 8 in. clamped to the wooden piles of the staging, the lower one about 3 ft. above low-water and the upper one about 15 ft. higher, and were driven by means of two water jets actuated by a steam pump playing at the foot of the pile, and generally it was possible to sink the piles to an average depth of 15 ft. into the sand in from 3 to 4 hours.

It was found that considerable erosion had taken place, due, in the writer's opinion, to the staging causing an obstruction in the course of the tides, which flow very strongly, having a rate at spring tides of four knots an hour, and by the comparative easiness found in sinking the piles it was decided to lengthen one pile by 14 ft. 6 in. and try to what further depth it was possible to sink the piles.

This pile was broken down to the follow, which was filled up with cement concrete of the same richness as the pile, and the junction made in the following manner. The lengthening bars were butted to the bars in the corners of the existing pile, and the joint strapped by a sleeve 2 ft. 6 in. long. Additional bars, 1¾ in. diameter and 6 ft. long, were placed in the sides of the pile, covering the joint equally, and the lacing with the $\frac{3}{16}$-in. steel wire continued as in the existing pile. Moulding boards 3 in. thick, of the necessary length, were clamped to two opposite sides of the pile and set up plumb, and the open sides closed up with 1-in. boarding 6 in. broad, as the concrete was filled in, the concrete being carefully and well rammed until it formed a jelly-like mass. When the concrete was thoroughly set and the moulding boards removed the piles presented a very smooth surface which required no filling in. The water jets were then fitted on the pile, the pump started and the pile sunk a further depth of 13 ft., making a total depth of 26 ft. 8½ in. into the sand, when a hard bottom was reached. It was then decided to lengthen the remaining piles by 13 ft. After the piles were broken down to the follow, which was filled with cement concrete, they were lengthened and sunk, an average depth of 26 ft. 9 in. into the sand being obtained, making an average depth below l.w.o.s.t. of 52 ft. A set test was then applied to the piles, the result being from ¾ in. to ⅞ in. for the last four blows of a 2½ ton monkey falling 4 ft., that required by the specification being 1 in.

The main—*i.e.*, centre—pile was enclosed by a cylinder, 5 ft. diameter, sunk 10 ft. into the sand; the sand was excavated and it was filled with cement concrete to the level of the main bracing. The cylinder was also sunk by the use of the water jets, six being applied inside and six outside, pressure being added by the use of two 50-ton hydraulic jacks, as the progress with the jets only was very slow.

30.a

CONCRETE BLOCK CHIMNEY IN COURSE OF CONSTRUCTION.

32.a

VIEW OF THE CONCRETE BASE OF A CHIMNEY.

The piles were placed in an octagonal form, having a centre pile 2 ft. sq., an inner ring of 18 in. sq. piles at a radius of 9 ft. 9 in., and an outer ring of 2 ft. sq. piles at a radius of 20½ ft., the heads of the piles being connected by radial and ring beams at a level of 4 ft. below h.w.o.s.t.

From each of the piles columns 18 in. diameter, with the exception of the centre one, which was 2 ft. diameter, were carried up to the level of the first floor, which is 21 ft. above the main bracing.

The first floor is carried by radial beams, inner and outer ring beams, with secondary radial beams from the inner ring beams to the outer edge of the gallery, which is 5 ft. wide and carried by a continuation of the radial beams in the form of a cantilever from the outer ring of columns.

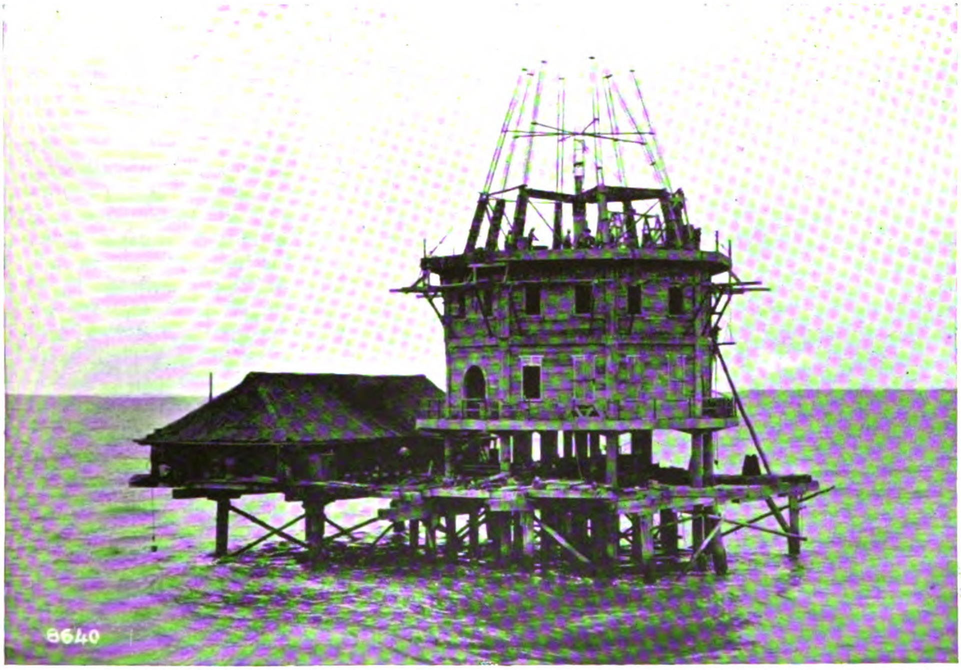
From the first to the third floor, a height of 24 ft. on the line of the outer ring beams, the space was walled in by walls 4 in. thick, strengthened by $\frac{5}{16}$-in. diameter bars laid vertically and horizontally 6 in. apart, and the centre column carried up for the same height and moulded to the same section as that below the level of the first floor. At the corners over the outer ring columns are five-sided pillars projecting 4½ in. beyond the outside of the wall to the height of the third floor, strengthened by four vertical bars 1¼ in. diameter, and laced every 6 in. by $\frac{3}{16}$-in. diameter wire. Midway between the corner pillars are pillars 12 in. by 10 in. flush with the wall on the outside, the four strengthening bars being ½ in. diameter and laced every 6 in. with ⅛-in. diameter wire. There is a second and a third floor, and above the latter are the service floors and the actual beacon floor.

The time employed in the construction of the lighthouse from the time the piles were sunk was twelve and a half months, and for the erection and fitting up of the lantern and apparatus, which together weighed 17½ tons, six weeks.

The total weight of the structure is approximately 997 tons.

The temporary wooden staging was erected by Mr. Thomas, who also constructed the reinforced concrete piles for the foundation of the lighthouse, when, owing to his departure for Australia, the contract was transferred to Messrs. Riley, Hargreaves & Co., Ltd., Singapore, who completed the contract.

Mr. John Craig was Resident Engineer on the work and supervised the construction on behalf of the Government. He has contributed a detailed article on the subject of this lighthouse to the *Engineering Review*, to whom we are indebted for the loan of the illustrations presented and the particulars published.



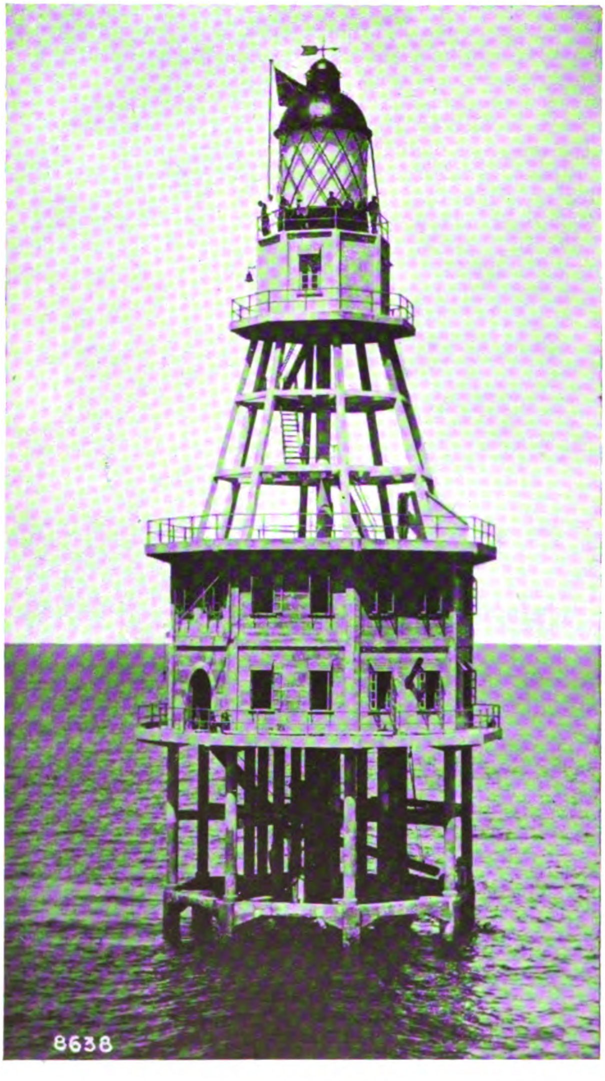
By courtesy of " The Engineering Review."

ONE FATHOM BANK LIGHTHOUSE, STRAITS OF MALACCA.
(Constructed in reinforced concrete.)

REINFORCED CONCRETE RAILWAY SLEEPERS IN THE UNITED STATES.

The successful reinforcing of concrete to resist impact has led to the application of this form of construction to railway sleepers in the United States, and what was obviously originally an experiment has been proved practical in a severe test now being conducted on the Pennsylvania line west of Pittsburg.

From particulars issued by the New York Railroad Club it would appear that reinforced concrete sleepers have been in use at Scully Yard for two years. Further, the Interborough Rapid Transit, New York City, has had some of these sleepers on its west track at Dyckman Street station since July, 1905. The Philadelphia Rapid Transit also have some of these sleepers on their Walnut Street surface road. So far all these specimens have given satisfaction. In particular it should be mentioned that at Scully Yard Mr. W. D. Wiggins, Engineer of Maintenance and Way, under a report dated April, 1908, states: "Several of the ties have been damaged by derailed cars, but have not been broken," which speaks well for the sleepers.



By courtesy of "The Engineering Review."
One Fathom Bank Lighthouse, Straits of Malacca.

Some explanation of the special form of the sleepers here under review may be given. They comprise spirals or "rolls" of reinforcing metal placed in a form, and squared by pressure and a mixture of sand and cement. The holes for the fastening device are made by steel pins being pressed through the tie by means of a template. They are exact. The pins are withdrawn before the tie hardens.

The fastening device for fastening rail is shown in *Fig.* 2. A small shell of galvanised steel is coiled into a hollow frustrum of a cone. Into the large end of the cone is inserted a spiral spring of proper pitch to mesh with threads of a ¾-in. commercial lag screw. The shell with spring is inserted in the conical hole at bottom of tie indicated in *Fig.* 3.

The lag screw is passed through a clip engaging the flange of the rail and screws into the spiral spring until the rail is tightly clamped to the tie. In practice a hard wooden block is placed below the rail. This deadens the shock. In the case of the Interborough Rapid Transit Road, and also the Philadelphia Rapid Transit, the block has stood and shows no deterioration, although ½ in. thick in the case of the first road mentioned.

Mr. Chenoweth in his paper before the Railroad Club said:

"The block used on the steam road at Scully had to be renewed, as the rail cut into the blocks in a very short time. I suggested a steel tie-plate to be placed on top of the blocks. The plates were ordered, not before some of the wooden blocks had been cut through, leaving the rail to pound upon the concrete tie. The effect was to damage the tie under the rail, which was observed on four of the ties, about 2 per cent.

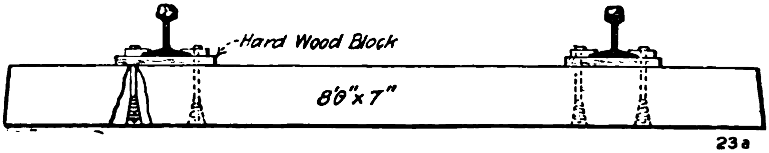


Fig. 3. Reinforced Concrete Railway Sleeper.

"This Scully track deserves some notice. There was no indication of any track force having given it much attention, being used to transport freight and coal cars. Iron from Carnegie Iron Works, trains loaded, moving over the line every five minutes day and night. The rail was light, cross-ties were placed 22 in. from centre to centre; spliced bars fastened to rail with four bolts, never tight; joints working loose, ballasted with column and ashes. The lifetime of a wooden tie, from six months to eighteen months. This is where the test was given to this form of concrete tie. They are still in the track. The fastening of the rail used was as described."

The lifetime of a wooden tie in the States has been given as from six to eight years, due to decay largely and to crushing from heavy loads. Concrete ties would be indestructible and cost very little more than wooden ties, when manufactured by the railroads themselves.

In practice, concrete ties should be placed about 10 in. apart, with a wooden block under rail. This wooden block in steam roads should have a steel plate on top, below the rail, to increase the bearing surface of the lower flange of rail. The rail should not be less than 100 lb. per yd. In electric or street roads the steel plate can be omitted.

The Report of the Board of Railroad Commissioners of the State of New York, for the year ending June 30th, 1906, states, on the Boston and Maine Road, which has 2,287 miles of track, renewals cost $712,644 (=£142,548 16s.). The life of a sleeper is eight years.

On the New York Central and Hudson River Railroad, with 3,580 miles of track, the renewals cost $1,077,973 (=£215,594 12s.), and the lifetime of a sleeper is eight years.

On the New York, Newhaven and Hartford Railroad the lifetime of a sleeper is, however, stated to be only six years.

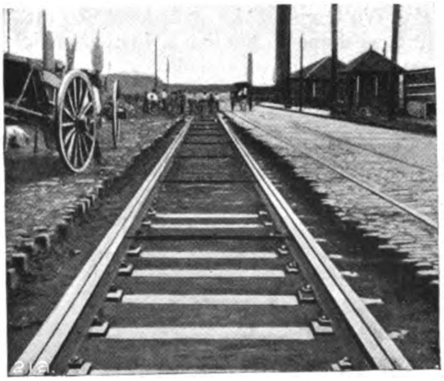


Fig. 1. Reinforced Concrete Railway Sleepers on the Philadelphia Rapid Transit Railway.

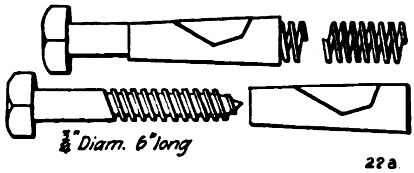


Fig. 2.

When one thus looks over the figures one can form some idea of the magnitude of the field.

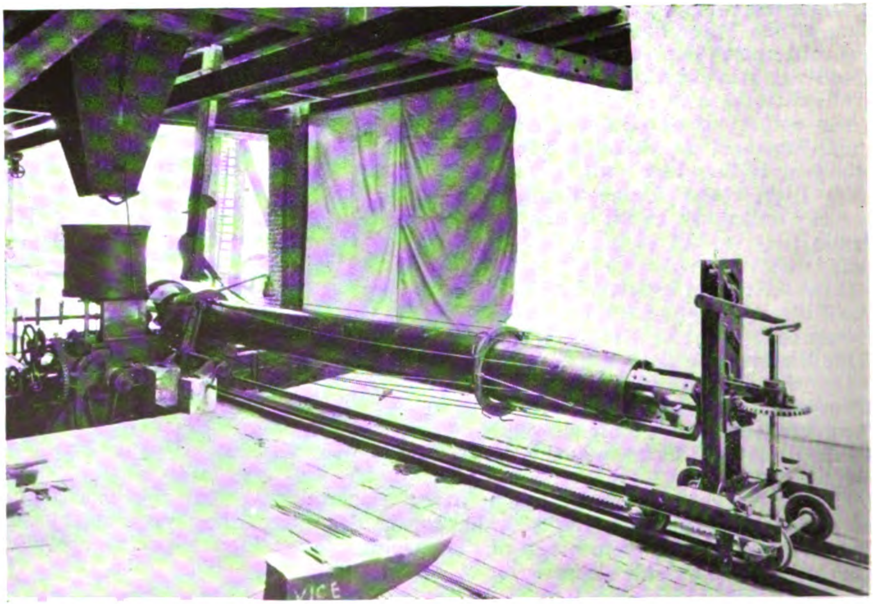
The sleeper account can be taken from the operating expense and placed in the bonded indebtedness as the physical value can be determined, being permanent value. This will divert a large percentage of the earnings to the interest-paying account by furnishing a more durable sleeper.

WEAVING CONCRETE POLES.

Concrete is used for many purposes nowadays, but a new development has just taken place by the installation of a machine at the works of the Cubitt Concrete Construction Company at 260 Gray's Inn Road, London, W.C., by Messrs.

Siegwart, Ltd., of Lucerne, which automatically manufactures hollow tapering concrete poles or posts for conveying electricity either for telegraph, tramway or electric light purposes, as well as pipes for conveying water, gas, sewage, etc., under pressure. The concrete of which these are formed is simply strengthened with steel wires or rods of small size, by the aid of which poles as long as 40 ft. are made extremely light in weight (the thickness of the shell being 1 to 2 in.) yet as strong as iron poles. The method of manufacture is novel and interesting. The concrete is handled in a revolutionary manner—in two senses. A small conveyor belt under great pressure wraps, in a spiral manner, a layer of concrete and a bandage of cloth round a metal core which has the wires or rods fastened to it. Thus rotating and gradually issuing from the machine the pole or pipe is immediately completed except for the withdrawal of the core and the removal of the bandage after the concrete has been allowed a short time in which to harden. The cost of these concrete poles is considerably less than iron or even wooden poles of long length, to both of which they are superior as regards appearance and durability, being, in fact, practically everlasting, and requiring no painting. The pipes, manufactured in a similar manner, are made up to 20 ft. in length and 2 ft. dia. They will withstand considerable pressure and take the place of iron pipes for water and gas mains, sewers, etc., over which it is stated that they have the advantage of much greater durability and considerable economy.

We have previously referred to Messrs. Siegwart's work in our issue of May, 1907, and we hope to publish a further article at an early date.



MACHINE FOR WEAVING REINFORCED CONCRETE POLES

NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED

REINFORCED CONCRETE COAL BUNKERS AT HOME AND ABROAD.

THE use of reinforced concrete for coal bunkers is becoming so very frequent that the description of the following examples at Warrington and at Monte Video may be of interest.

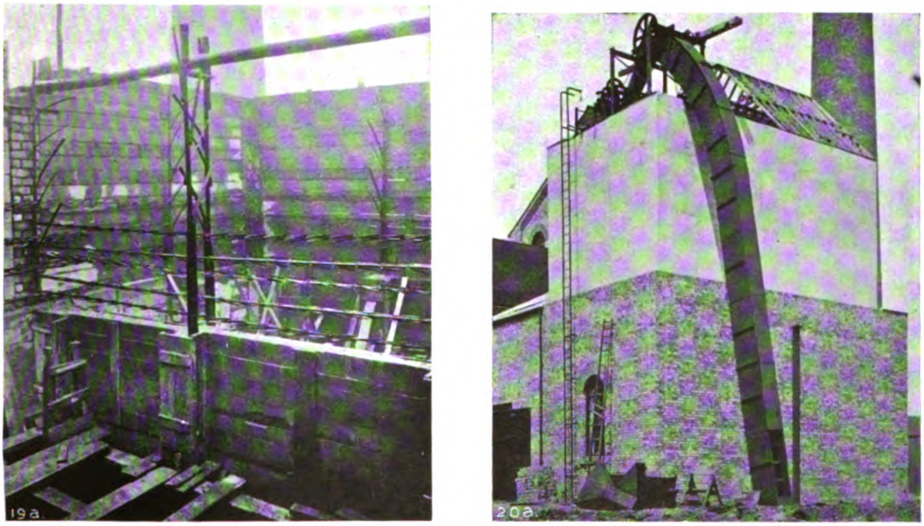
Bunker for the Warrington Corporation Electricity Department.—The bunkers for the Warrington Corporation have only a capacity of some 250 tons. They are, however, interesting from a reinforced concrete point of view, for though small, the type of construction here shown was found to be cheaper than the steel bunkers at first designed, and their life should certainly be very much longer.

The bunkers are 32 ft. 6 in. long, 19 ft. 9 in. wide, and 17 ft. 2 in. high. The walls are 6 in. thick at the base, tapering to 4 in. at the top. The reinforcement of the wall panels, which throughout is on the Kahn system, consists of ½ in. Trussed bars placed horizontally and sheared full length "one way." They are on 6 in. centres at the base, diminishing to 18 in. at the top, the diagonals of each succeeding bar pointing in the reverse direction. About every 6 ft. 6 in. are 22 in. × 10 in. buttresses, reinforced with one 1¼ in. Trussed bar; they are tied across by 1 in. and ¾ in. rods, looped and made fast round the buttress tension member, the top ties being concreted into cross beams. The division wall is also 6 in. thick, tapering to 4 in., has two 2 ft. × 10 in. buttresses, tied top and bottom as before, and is reinforced by ½ in. Trussed bars, sheared as described, and placed horizontally towards each side alternately, at from 4½ in. centres at the base, diminishing to 9 in. at the top.

The concrete decking of the bottom is 5 in. thick, with ½ in. Trussed bars on 12 in. centres; the whole resting on supports provided by owners.

The concrete used was a 1 : 2 : 3 mix, and the aggregate Whinstone chippings, to pass as ¾ in. ring.

Messrs. John Tanner & Sons, of Liverpool, were the contractors.



REINFORCED CONCRETE COAL BUNKERS AT WARRINGTON.

Reinforced Concrete Coal Bunker at Monte Video. — In accordance with the original design, the bunker was to be 300 ft. long, but as executed, because of difficulties with regard to the foundations, the internal dimensions were limited to 156 ft. × 48 ft. × 20 ft., with a capacity of about 3,200 tons.

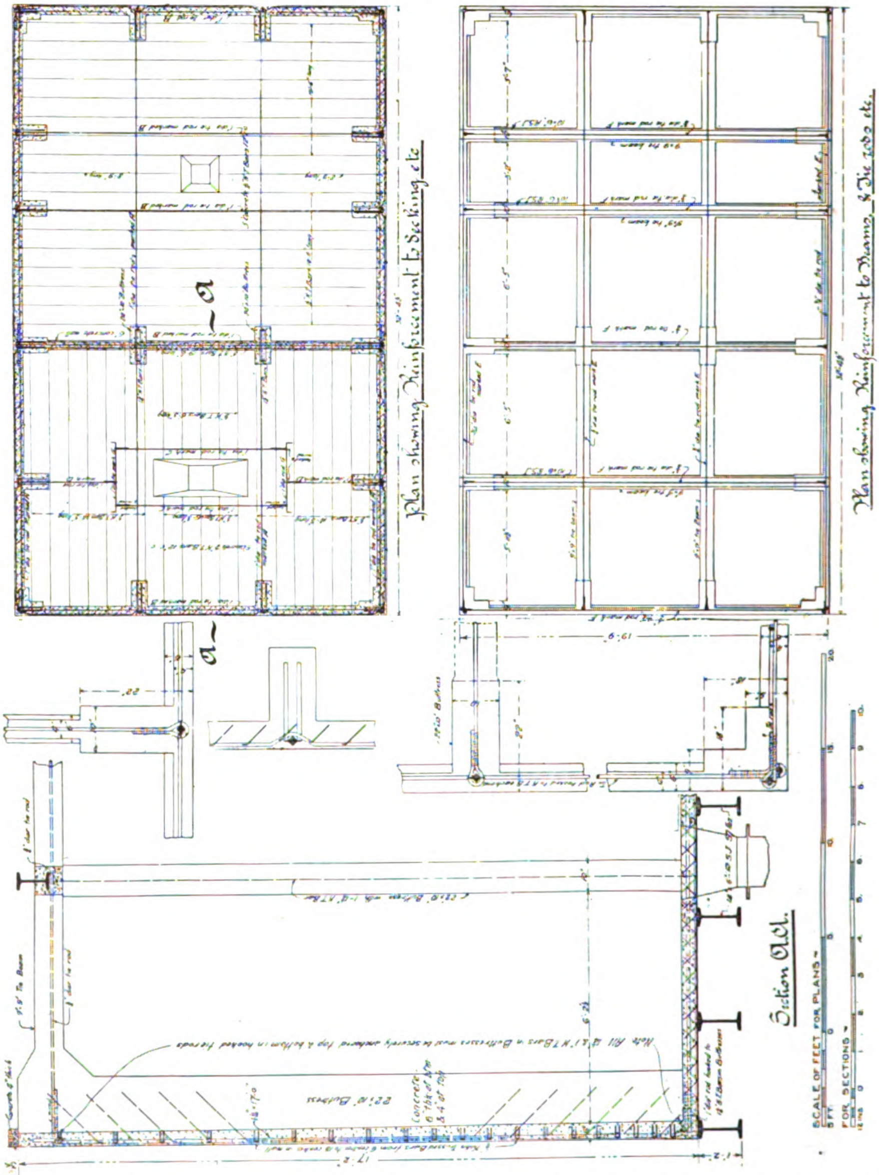

Plan showing Reinforcement & Decking etc.
Plan showing Reinforcement to Beams & Ties etc.
A
A
Section A.A.
SCALE OF FEET FOR PLANS
FOR SECTIONS

FIG 1.—DETAILS OF REINFORCED CONCRETE COAL BUNKERS FOR THE WARRINGTON CORPORATION ELECTRICITY DEPARTMENT.

From the accompanying drawings it will be seen that the walls of the structure are united to the floor by means of diaphragms enclosing the anchor ties in such a manner that the whole portion of the floor between the diaphragms, which are 9 ft. 6 in. apart, would have to be uplifted with the walls before overturning could take place. The overturning pressure being supplied by the coal to be contained in the bunker, it becomes apparent that the latter, whilst causing the pressure, also supplies the necessary vertical weight to resist overturning. In this way, by a judicious arrangement of proportions, it is possible to obtain a retaining wall whose mass is largely supplied by the retained material.

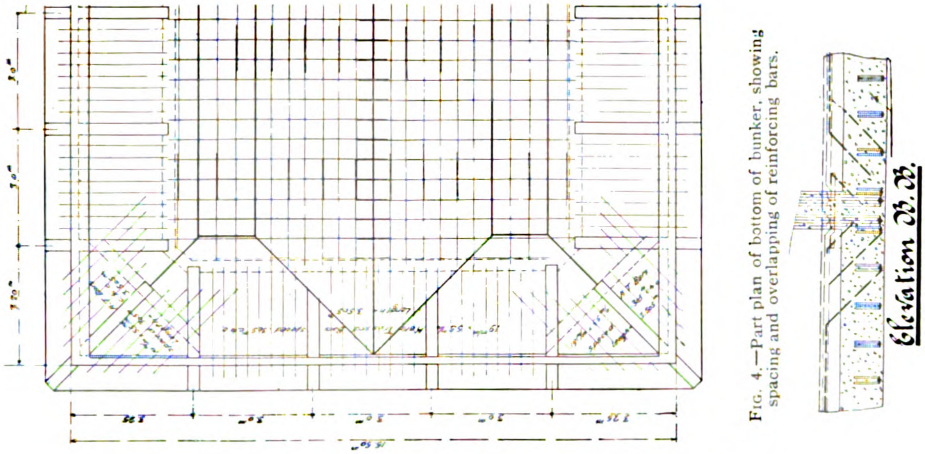


FIG. 4.—Part plan of bottom of bunker, showing spacing and overlapping of reinforcing bars.

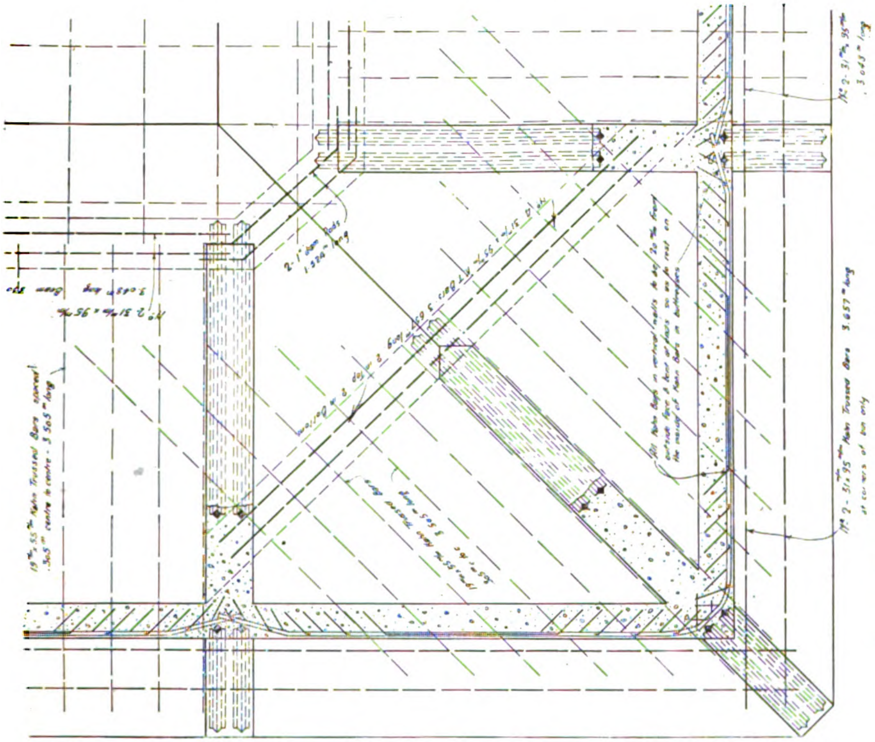


FIG. 2.—REINFORCED CONCRETE COAL BUNKER AT MONTE VIDEO. (Sectional plan of corner of bunker.)

The outside shell of the wall is designed to resist possible bending from side pressure, while the top of the walls are designed to act as crane tracks for the handling of the coal.

The bunker was designed by the Trussed Concrete Steel Co., of Caxton House, Westminster, Kahn Trussed Bars being used throughout for reinforcement, and the drawings presented explain themselves.

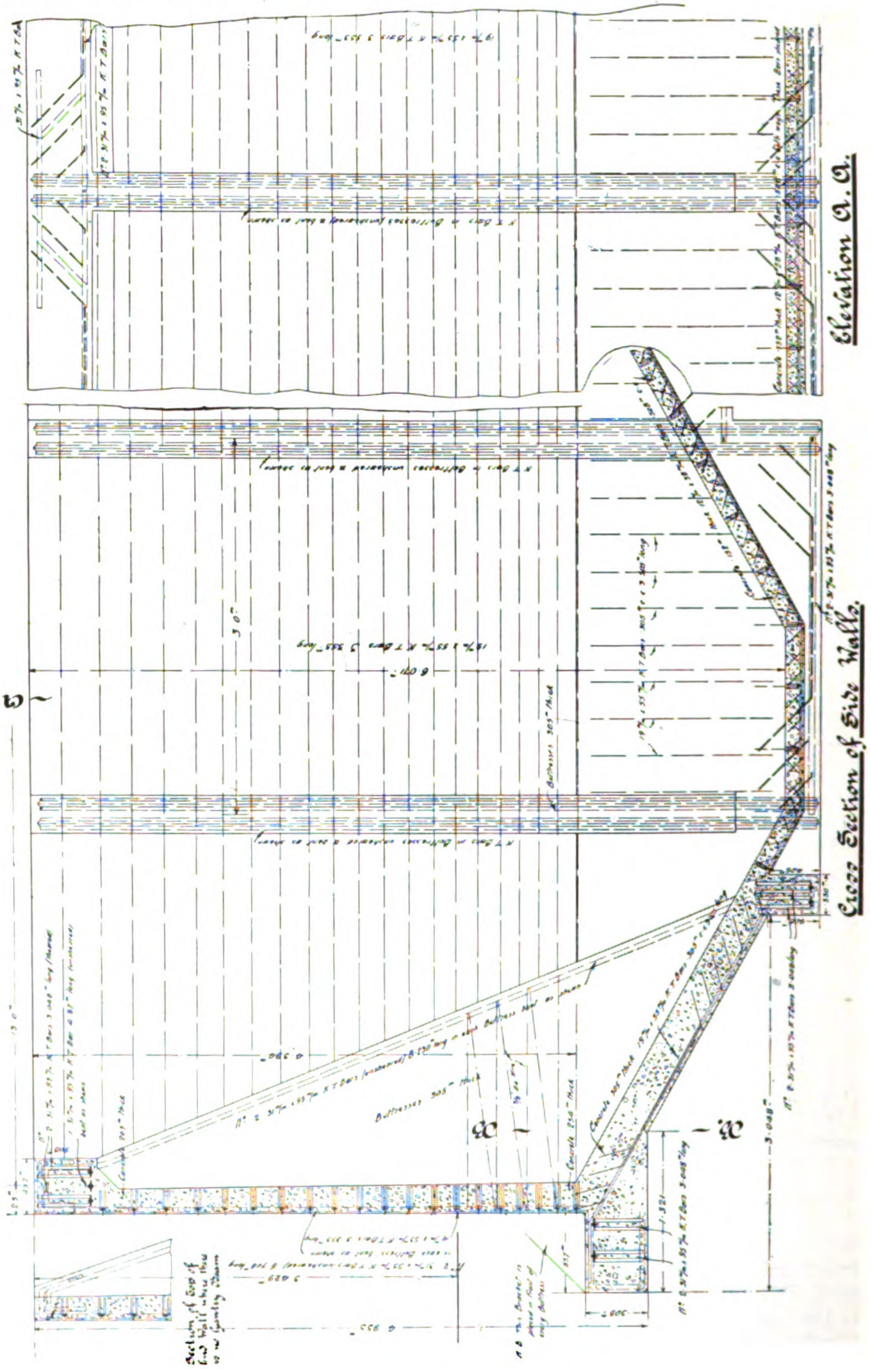


FIG. 3.—REINFORCED CONCRETE COAL BUNKER AT MONTE VIDEO.

LAWS, RULES, AND REGULATIONS

AT HOME AND ABROAD.

The necessity of framing special regulations for the control of buildings and constructional works of concrete and of steel is being generally recognised, and new codes of rules are being issued in different parts of the world by governments, municipalities, underwriters, and estates. Important Laws, Rules, and Regulations will be published in full or in extract under this heading, for they will not only serve as a guide to those who assist in the preparation of such measures, but also to those engineers and architects who, in the absence of regulations, are anxious to safeguard the interests of their employers by specifying their work to meet the eventualities of time or unusual strain.—ED.

Rules Recommended by National Board of Fire Underwriters for Reinforced Concrete Buildings.

The term "reinforced concrete" or "concrete-steel" in this Section shall be understood to mean an approved concrete mixture reinforced by steel of any shape, so combined that the steel will take up the tensional stresses and assist in the resistance to shear.

Reinforced concrete construction may be accepted for fireproof buildings, if designed as hereinafter prescribed, provided that the aggregate for such concrete shall be hard-burned broken bricks, or terra-cotta, clean furnace clinkers, entirely free of combustible matter, clean broken stone, or furnace slag, or clean gravel, together with clean siliceous sand, if sand is required to produce a close and dense mixture; and provided, further, that the minimum thickness of concrete surrounding and reinforcing members one-quarter inch or less in diameter shall be one inch; and for members heavier than one-quarter inch the minimum thickness of protecting concrete shall be four diameters, taking that diameter, in the event of bars of other than circular cross-section, which lies in the direction in which the thickness of the concrete is measured; but no protecting concrete need be more than four inches thick for bars of any size; and provided, further, that all columns and girders of reinforced concrete shall have at least one inch of material on all exposed surfaces over and above that required for structural purposes; and all beams and floor slabs shall have at least three-quarters inch of such surplus material for fire-resisting purposes; but this shall not be construed as increasing the total thickness of protecting concrete as herein specified.

All the requirements herein specified for protection of steel and for fire-resisting purposes shall apply to reinforced concrete filling between rolled-steel beams, as well as to reinforced concrete beams and to entire structures in reinforced concrete. Any concrete structure or the floor filling in same reinforced or otherwise, which may be erected on a permanent centering of sheet metal, of metal lathing and curved bars, or a metal centering of any other form, must be strong enough to carry its loads without assistance from the centering, unless the concrete is so applied as to protect the centering as herein specified for metal reinforcement.

Exposed metal centering or exposed metal of any kind will not be considered a factor in the strength of any part of any concrete structure, and a plaster finish applied over the metal shall not be deemed sufficient protection.

All concrete for reinforced concrete construction whenever used in such buildings must be mixed in a machine which mixes one complete batch at a time, and entirely discharges it before another is introduced. At least twenty-five complete revolutions must be made at such a rate as to turn the concrete over at least once in each revolution for each bath.

Before permission to erect any concrete-steel structure is issued, complete drawings and specifications shall be filed with the Commissioner of Buildings, showing all details of the construction, the size and position of all reinforcing rods, stirrups, &c., and giving the composition of the concrete.

The execution of work shall be performed by workmen under the direct supervision of a competent foreman or superintendent.

All forms and centering for concrete shall be built plumb and in a substantial manner with inside surfaces smooth and made tight, so that no part of the concrete mixture shall leak out through joints, cracks or holes, and after completion shall be thoroughly cleaned out, removing shavings, chips ,pieces of wood and other material, which should not be permitted in forms.

The reinforcing steel shall be accurately located in the forms and secured against displacement while the concrete is being placed and tamped.

Concrete shall be placed in forms as soon as practicable after mixing, and in all cases immediately after the addition of water.

Whenever fresh concrete joins concrete that is set, or partially set, the surface of the old concrete shall be roughened, cleaned and thoroughly slushed with a grout of neat cement and water.

Concrete shall not be installed in freezing weather; such weather shall be taken to mean a temperature of thirty--two degrees Fahrenheit or lower; concrete shall not be allowed to freeze after being put in place, and, if frozen, shall be removed.

The time at which forms and centering may safely be removed will vary from twenty-four hours to sixty days, depending upon temperature and other atmospheric conditions of the weather; the time for such removal to be determined by the Commissioner of Buildings.

The concrete shall be mixed in the proportions of one of cement, two of sand and four of other aggregates as before provided; or the proportions may be such that the resistance of the concrete to crushing shall not be less than 2,000 pounds per square inch after hardening for twenty-eight days, but for reinforced or plain concrete columns the mixture shall not be leaner than one part of cement, two of sand and five of the coarser aggregate in any case. The tests to determine this value must be made under the direction of the Commissioner of Buildings. The concrete used in concrete-steel construction must be what is usually known as a " wet " mixture.

Only high-grade Portland cements shall be permitted in reinforced concrete-steel constructed buildings. Such cements, when tested neat, shall, after one day in air, develop a tensile strength of at least 300 pounds per square inch; and after one day in air and six days in water shall develop a tensile strength of at least 500 pounds per square inch; and after one day in air and twenty-seven days in water shall develop a tensile strength of at least 600 pounds per square inch. Other tests, as to fineness, constancy of volume, &c., made in accordance with the standard method prescribed by the American Society of Civil Engineers, may, from time to time, be prescribed by the Commissioner of Buildings.

The sand to be used must be clean, sharp grit sand, free from loam or dirt, and shall not be finer than the standard sample kept in the Department of Buildings.

The stone used in the concrete shall be a clean, broken stone, of a size that will pass through a three-quarter inch ring, or good gravel may be used in the same proportion as broken stone, or broken hard bricks, or terra-cotta, or furnace slag, or hard clean clinkers may be used.

The steel shall meet the requirements of Section 21 of this Code.*

Concrete-steel shall be designed in accordance with the following assumptions and requirements :—

(1) The adhesion between the concrete and the steel is sufficient to make the two materials act together; the unit value of the adhesion is at least equal to the unit shearing strength of concrete.

(2) The design shall be based on the assumption of a load four times as great as the total working load (ordinary dead load plus ordinary live loads) producing a stress in the steel equal to the elastic limit, and a stress in the concrete equal to two thousand pounds per square inch.

(3) The modulus of elasticity of concrete at two thousand pounds per square inch is equal to one-eighteenth of the modulus of elasticity of steel.

(4) The steel takes all the tensile stress.

(5) The stress-strain curve of concrete in compression, when the stress in the extreme fibre is two thousand pounds per square inch, may be assumed.

(a) As a straight line.

(b) As a parabola with its axis vertical and its vertex on the neutral axis of the beam, girder or slab, or

(c) As an empirical curve with an area one-quarter greater than if it were a straight line, and with its centre of gravity at the same height as that of the parabolic area assumed in (b).

(6) The assumption belonging to the common theory of flexure, where not modified by any of the foregoing, will apply.

In the design of structures involving reinforced concrete girders and beams, as well as slabs, the girders and beams shall be treated as T-beams, with a portion of the slab acting as flange, in each case. The portion of the slab so acting shall be determined by assuming that in any horizontal-plane section of the flange, the stresses are distributed as the ordinates of a parabola, with its vertex in the stress-strain curve and with its axis in a longitudinal vertical plane through the centre of the rib of the T.

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*Section 21. STEEL. All structural steel shall have an ultimate tensile strength of from 54,000 to 64,000 pounds per square inch. Its elastic limit shall be not less than 32,000 pounds per square inch, and test specimens, ruptured in tension, must show a minimum elongation of not less than 20 per cent. in eight inches. Rivet steel shall have an ultimate strength of from 50,000 to 58,000 pounds per square inch.

The shearing strength of concrete, corresponding to a compressive strength of two thousand pounds per square inch, shall be assumed at two hundred pounds per square inch.

All reinforced concrete T-beams must be reinforced against the shearing stress along the plane of junction of the rib and the flange. Where reinforced concrete girders carry reinforced concrete beams, the portion of the floor slab acting as flange to the girder must be reinforced with bars near the top, at right angles to the girder, to enable it to transmit local loads directly to the girder and not through the beams, thus avoiding an integration of compressive stresses due to simultaneous action as floor slab and girder flange.

Concrete indirect compression shall not be stressed, under the working load, more than three hundred and fifty pounds per square inch. Reinforced compression members shall be designed on the assumption that this stress in the concrete will be simultaneous with one of six thousand pounds per square inch in the steel. Should the use of hooped concrete be proposed, the working stresses will be a subject of special consideration by the Commissioner of Buildings.

In the execution of work in the field, work must be so carried on that the ribs of all girders and beams shall be monolithic with the floor slab.

In all reinforced concrete structures, special care must be taken with the design of joints to provide against local stresses and secondary stresses due to the continuity of the structure.

In the determination of the bending moments due to the external forces, beams and girders shall be considered as simply supported at the ends, no allowance being made for continuous construction over supports. Floor plates, when constructed continuous and when provided with reinforcement at top of plate over the supports, may be treated as continuous beams, the bending moment for uniformly distributed loads being taken at not less than $\frac{WL}{10}$; the bending moment may be taken at $\frac{WL}{20}$ in the case of square floor plates which are reinforced in both directions and supported on all sides.

When the shearing stresses developed in any part of a reinforced concrete or concrete-steel constructed building exceed under the multiplied loads the shearing strength as fixed in this Section, a sufficient amount of steel shall be introduced in such a position that the deficiency in the resistance to shear is overcome.

When the safe limit of adhesion between the concrete and steel is exceeded, provision must be made for transmitting the strength of the steel to the concrete.

Concrete-steel may be used for columns in which the ratio of length to least side or diameter does not exceed twelve. The reinforcing rods must be tied together at intervals of not more than the least side or diameter of the column.

The contractor must be prepared to make load tests on any portion of a reinforced concrete or concrete-steel constructed building within a reasonable time after erection as often as may be required by the Commissioner of Buildings. The tests must show that the construction will sustain a load with a factor of safety for floors and structural members as required by Section 136 of this Code.*

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*Section136. FACTORS OF SAFETY

Where the unit stress for any material is not prescribed in this Code the relation of allowable unit stress to ultimate strength shall be—

As one to four for metals, subjected to tension or transverse stress;

As one to six for timber;

And as one to ten for natural or artificial stones and brick or stone and masonry.

But wherever working stresses are prescribed in this Code, varying the factors of safety herein above given, the said working stresses shall be used.

MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Question and Reply in the House of Commons Regarding Coal Residues in Reinforced Concrete.—Mr. Ridsdale recently put a question in the House of Commons to the President of the Local Government Board, on the subject of Coal Residues in Reinforced Concrete. Question and reply are as follows, but we refer to the matter editorially, as the German coal residues referred to differs from what we know as coke breeze, and as a matter of fact the material has not been prohibited throughout Germany, but the Prussian Ministry of Public Works has simply issued some precautionary recommendations on the matter :—

Question of Mr. Ridsdale, M.P.	*Reply of the President of the Local Government Board (Mr. John Burns, M.P.).*
If he was aware that the use of coal residues in reinforced concrete for building purposes had been forbidden throughout Germany on account of its danger; whether such materials were in common use in this country; and if so what steps, if any, he proposed to take?	*I have no official information as to the use of the materials referred to being prohibited for building purposes in Germany. I have, however, seen some statements in the newspapers to this effect. I am aware that these materials are in common use in this country, and I propose to obtain some further information as to the result of such use, and also as to how the matter has been dealt with in Germany.*

Death of Mr. James Sheppard.—It is with great regret that we announce the death of Mr. James Sheppard, surveyor of the North British and Mercantile Insurance Co., who has contributed on several occasions to our columns. Mr. Sheppard, who died at the age of sixty-eight, was one of the few insurance surveyors who took a wider view of his duties than is generally the case with his colleagues, who so often limit their activities to surveying from the orthodox insurance point of view—namely, that of merely taking risks as they find them and fixing a " rate."

Mr. Sheppard, on the other hand, was always anxious to improve the fire risks and a strong advocate of fire prevention as obtainable by more careful and better construction, and it is not too much to say that he ranked as one of the highest authorities on all matters of fire prevention and building construction from the fire-protective point of view, both at home and abroad; his name also being a household word in fire-service circles as far distant as our Australasian Colonies.

For many years the late Mr. Sheppard was an active member of the British Fire Prevention Committee, and it was under his direction that many of the valuable tests undertaken by that body were carried out.

His contributions on matters relating to the fire resistance of concrete and reinforced concrete were most valuable, and it should be remembered that he took a very strong view that it was not only the precise number of inches of covering accorded to the metal work that was a matter of moment, but also the precise components of the concrete used and the manner of its application.

The deceased was a member of the Council of the London Insurance Institute, and a member of many technical societies. He was also an honorary member of numerous home and foreign fire service corporations, and held various distinctions—notably the Gold Medal of Merit of the Russian Government, which was accorded to him for his research work in building construction.

It was characteristic of Mr. Sheppard's interest in matters of building generally that he was one of the first hundred founders of the Concrete Institute.

The Will of the Late Mr. L. G. Mouchel.—Mr. Mouchel's will may be summarised as follows:—

> Mr. L. G. Mouchel, of Iddesleigh Mansions, Caxton Street, S.W., and of Victoria Street, S.W., civil engineer, sole agent in the United Kingdom for the Hennebique Ferro-Concrete Construction Company, Limited, largely interested in the Colonial Ferro-Concrete Syndicate, Limited, the Liverpool Hennebique Ferro-Concrete Contracting Company, Limited, and the Yorkshire Hennebique Ferro-Concrete Contracting Company, Limited, a native of Cherbourg, who died on May 27, aged 56, a citizen of the French Republic, but domiciled in the United Kingdom, left estate valued at £79,570 gross, with net personality £68,384. He stated that he formed his London business into a company in 1907 to enable members of his staff to participate in the business, and he directed that his holding in the said company should be offered at par and his holdings in the various ferro-concrete companies and syndicates at their fair or market value to the other shareholders in the company which he had formed. The residue of his property the testator left as to one-tenth (over £6,000) equally between Dr. Barnardo's Homes, the Salvation Army for general purposes of that institution, the Civil Hospital at Cherbourg, the Bureau de Bienfaisance, Cherbourg, L'Etablissement des Orphelines de Ste. Marie, Cherbourg, and La Société de Secours des Naufrages de France, Paris.

Concrete Construction at Scarborough.—The new Marine Drive, which has just been formally opened, has been under construction since the summer of 1897, but owing to numerous difficulties, and the havoc caused by storms, the completion of the work has been continuously delayed.

The sea wall of the drive is 4,200 ft. in length, and varies in height from 22 ft. to 40 ft. It is built upon Oxford clay or blue shale, and the foundations are 4 ft. below low-water mark. The wall has a concave front to the sea, and is constructed entirely of cement concrete, whilst the face and a portion of the back, in the more exposed portions of the work, are built up of blocks varying from 1·5 to 9 tons each, made of 6 to 1 concrete, and backed with 8 to 1 mass concrete. The space behind the wall has been filled with material scarped from the face of the cliff, and upon this has been constructed the promenade and drive. The promenade is 20 ft. in width and is paved with concrete laid *in situ* on an underbed of 12-in. 8 to 1 concrete. On the more exposed portions of the work the roadway is paved with 2 ft. concrete blocks.

The original contract was for £69,270, but the actual cost to date has been, roughly, £105,000 for the drive and promenade, and £17,161 for the construction of the approach from the West Pier to the south-east corner of the Drive, for the purchase of property and other matters.

Proposed Water Reservoir for Calcutta.—Owing to the increase of the population in Calcutta it is proposed to erect an elevated steel tank of 32,000,000 gallons capacity, and as the ground in Calcutta has a poor bearing capacity it will be necessary to prepare a bed of reinforced concrete to carry it.

Reinforced Concrete Bridges in New Zealand.—We understand from a contemporary that reinforced concrete is being largely used for bridge building in New Zealand, and that some very fine examples have been constructed over the Oakura, in Taranaki. One bridge in particular, of rib-plate design, on abutments of reinforced concrete, of one span of 64 ft., with a width of 14 ft. 8 in., and a height of 28 ft., is mentioned as being one of the cheapest and best bridges built in that country.

Concrete Building in Mexico.—The American Consul-General in Mexico City reports that there is practically an unlimited future for the use of concrete as a building material in that city, as well as in the other large cities of the Mexican Republic, especially for hollow concrete blocks.

He states that in the capital city there are only some 300 houses at present which are constructed of concrete, but this is due to the fact that the material was not generally accepted by architects and builders until a very short time ago, owing to the fact that an endeavour was made some years back to place concrete blocks of poor quality upon the market, which were universally condemned. It is now expected that the use of concrete and reinforced concrete will become general.

LECTURES, PAPERS AND PAMPHLETS.

Association of Municipal and County Engineers.—In the paper recently read by Mr. C. S. Meik, M.Inst.C.E., before the above-named association, the principal example to which he referred at length were the piles which have been driven at the King's Dock at Swansea. These piles, which were constructed on the Hennebique system, were of 1 to 4 concrete, and were driven by a monkey weighing 50 cwt. falling a height of 10 ft. The piles were protected by a sawdust cap and sustained no damage. Mr. Meik also referred to the work done at Purfleet Pier, and gave some interesting statistics as to costs.

The International Navigation Congress.—Two very interesting Reports were presented before the above Congress at St. Petersburg by Mr. W. Noble Twelvetrees, M.I.Mech.E., on (1) Application of Armoured Concrete to Hydraulic Constructions, and (2) Application of Reinforced Concrete to Maritime Works. These Reports describe some of the best-known examples of this class of work in Great Britain, including River and Canal Work, Walls and Banks, Docks, Wharves and Jetties, Reservoirs, etc., in the first part, and Coast Protection Works, Harbour Works, and Lighthouse Construction in the second part. Both Reports are illustrated with plans setting out the construction of the structures described.

Association of Water Engineers.—At the annual meeting of this Association, at Birmingham, an interesting and instructive paper by Mr. R. O. Wynne-Roberts, M.Inst.C.E., was presented on the History and Description of Capetown Waterworks. The paper dealt most fully with the subject, and the various reservoirs and other works in which reinforced concrete had been applied were illustrated by photographs and plans.

CORRECTIONS.

The Stadium at the Franco-British Exhibition.—To correct any misapprehension which might arise from an article contained in our May issue under the title of "The Reinforced Concrete Stadium at the Franco-British Exhibition, 1908," we are desirous of stating that the design for this structure was prepared by Mr. J. J. Webster, M.I.C.E., and the contractors were Messrs. Alex. Findlay & Co., Ltd., of Motherwell.

The New Western District Post Office.—The correct name of the contractors for this building is Messrs. William King & Son (of 3, Vauxhall Bridge Road), and not W. King & Co., as stated in error in our last issue.

Mr. Workman, the agent in London for the Coignet System, has informed us that in connection with this building the name of Mr. Maurice Behar, chief engineer of the firm, should have been mentioned in conjunction with that of Mr. Workman as Specialist Engineer.

The United Kingdom Fireproofing Co., Ltd.—This firm have pointed out to us that the floor illustrated on page 241 of our July issue (*Fig.* 7) and which was used in all the corridors of the Manchester Royal Infirmary, is not the property of the National Fireproofing Co., as our article would seem to state, but was constructed by them, under an agreement with Mr. G. H. Gascoigne, their present managing director, who is the patentee.

A NEW COMPANY.

Edmond Coignet, Limited.—Mr. Edmond Coignet's business in Great Britain was registered on June 23rd as a limited company, with a capital of £40,000, in £1 shares.

Objects : To acquire and develop the system of reinforced or armoured concrete known as the Coignet System, and all patents and rights relating thereto, and the business carried on in connection therewith by E. Coignet in England, and to carry on the business of builders, contractors, makers of and dealers in cement, concrete, girders, beams, piles, uprights, standards, pillars, columns, and building requisites of all kinds, etc. No initial public issue. The first directors (to number not less than three nor more than seven) are: E. Coignet (chairman and permanent director), A. Lazard, and G. C. Workman. Qualification (except A. Lazard and G. C. Workman), 100 shares. Registered office, 20 Victoria Street, Westminster.

CONTRACTS.

Messrs. Robert McAlpine & Sons, of Glasgow and London, have secured the contract for the construction of a new power station at Dunston, near Newcastle, for the Newcastle Electric Supply Co. The work is to cost about £60,000, and its special feature is that, as the ground has a poor bearing capacity, the whole site is to be covered with a heavy concrete floor resting on piles. This floor is to carry a great weight of machinery, and the concrete is reinforced. For the same company Messrs. McAlpine are also boring tunnels under the Tyne and Wear.

Messrs. Howe Bros., of West Hartlepool. The North-Eastern Railway Company have now almost completed their additional warehouse at the Forth goods terminal, Newcastle-on-Tyne. The warehouse measures 220 ft. by 80 ft., and with the exception of the roof is constructed in reinforced concrete on the Hennebique system. The building has been erected to the designs and under the supervision of Mr. W. Bell, F.R.I.B.A., of York, Messrs. Howe Bros., of West Hartlepool, acting as contractors.

Messrs. D. G. Somerville & Co., of Westminster, inform us that they have at present in hand a very large contract for a new factory for the Kodak Company at Wealdstone. This building is 337 ft. long by 40 ft. wide, and consists of two floors and roof. They have also in hand a reinforced concrete bridge for the East Ashford Urban District Council, the spans being 47 ft. in the clear; the floors to the Anglo South-American Bank, Old Broad Street, all designed on the Kahn system, and a large telephone exchange at Deptford, in which round bars and Kahn trussed bars are used. In addition they are erecting a residence at Cowes, using Johnson wire lattice as reinforcement, and a covering to sewage tanks, in which indented bars are being employed.

D. G. SOMERVILLE & Co

THE SPECIALIST ENGINEERS AND CONTRACTORS IN

REINFORCED CONCRETE

THE illustration shows a large Bakery we erected for Messrs. McVITIE & PRICE at the Franco-British Exhibition. This building, which is entirely constructed in steel and concrete, shows the adaptability of reinforced concrete to artistic designing.

We have designed and completed hundreds of similar constructions, bridges, floors, wharfs, warehouses, retaining walls, tanks, reservoirs, etc. Pending the issue of our revised catalogue on reinforced concrete, we have published an interesting pamphlet illustrating numerous works carried out by us, and giving valuable information concerning reinforced concrete. We will be pleased to send you a copy on application. We are not tied to any particular system, so can recommend what we think the most economical and satisfactory scheme.

72 VICTORIA ST., S.W.

WORKS : ARCHANGEL WHARF
NEW CROSS

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume III. No. 5. NOVEMBER, 1908.

EDITORIAL NOTES.

THE LOCAL GOVERNMENT BOARD AND LOANS ON REINFORCED CONCRETE STRUCTURES.

THE extraordinary position of affairs regarding the loan periods for reinforced concrete buildings still exists, and we now actually hear that although the Association of Municipal Engineers, acting in co-operation with several other societies, has requested an opportunity of sending a deputation to the President of the Local Government Board with a view of explaining the anomalous state of affairs, nothing but pointed discourtesy was met with at the hands of Mr. John Burns' department. The Association had to wait months for anything beyond a formal acknowledgment of their request, and finally were given to understand that a deputation would not be welcome; in fact, that the powers that be are apparently solely inclined to accept written observations on the subject—*i.e.*, do not consider the matter as deserving the personal attention of their chief. Upon these written observations then being sent in, and another interval of a couple of months elapsing, we understand that the only reply vouchsafed has been to the effect that the Department sees no reason for changing its present policy.

Judging from the pointed discourtesy shown to the Association, which has a considerable membership—for the most part municipal engineers to local authorities in Great Britain—we have now reluctantly come to the conclusion that there is some question of bias making itself felt in the Local Government Board, as far as this subject is concerned, which is entirely foreign to the nature of the President who is responsible for that department, and who enjoys a reputation for fairness and common sense which it would be regrettable if he lost through the tactlessness or mismanagement of any of his officers.

We have on a previous occasion indicated what we think would be the right step on the part of the President of the Local Government Board—namely, to convene a Special Committee of Enquiry to report to him on the question of loan periods for reinforced concrete, such committee to comprise, among others, the representatives of the several public departments who use reinforced concrete and the societies primarily interested.

The present position is, of course, not merely economically serious but also farcical, and it does little credit to the Local Government Board and its President that it should have been allowed to exist so long.

Plainly stated, the position still is that a timber roof can be accorded a thirty years' loan period, but a reinforced concrete roof only a period of fifteen years. Groins of red deal are similarly accorded double the loan period allowed to reinforced concrete groins. Further, a local authority putting up the simplest reinforced concrete structure costing £1,000 is practically told by the Government that it must not expect it to last longer than fifteen years, whilst hundreds of thousands of pounds are being spent in reinforced concrete construction by the self-same Government where works of permanent value are intended.

We are afraid the whole matter is one of the individual likes and dislikes of some officer or officers of the Local Government Board—*i.e.*, a matter of bias, and no longer one of professional or technical importance. Thus the sooner Mr. John Burns puts a stop to this state of affairs with the aid of independent enquiry so much the better.

In the meantime we present below the written observations of the Association as addressed to the Local Government Board. The text of the reply has not yet been made public as we go to press, but, as indicated, it leaves matters in the regrettable *status quo ante*. The Municipal Engineers of Great Britain, as represented by their Association, have thus been just over six months trying to get some redress to their grievance, first by deputation and now by written memorandum, but up to the present have failed signally. Perhaps the local authorities themselves who have to pay the piper will now gradually take the matter up.

VIEWS OF THE MUNICIPAL ENGINEERS.

Period for Repayment of Loans for Reinforced Concrete Structures.

THE following letter on this subject has been addressed to the Right Hon. John Burns, President of the Local Government Board, by the Association of Municipal and County Engineers :—

Sir,—We have your letter of the 19th ult., and note that your board doubt whether the discussion of the question raised in our letter of March 10th would be of any advantage, but that they would be happy to consider any recommendations which we may wish to submit.

We therefore beg to place before you the following memorandum, and hope that on further consideration your board may relax their present attitude on this question, which appears to be based on the opinion that the durability of reinforced concrete work is not yet proved, and may grant the same periods for the repayment of loans on works in this material as on structures of brick, stone, or ordinary concrete.

We would, in the first place, point out that the action of your board in so restricting the period for repayment of loans largely prevents local authorities, who require your sanction as a condition precedent to obtaining the money for their undertakings, from adopting an economical form for construction much used in circumstances where the durability of the work is all-important by private owners, railway and dock companies, foreign governments, the Admiralty, the War Office, and the Office of Works.

We would respectfully submit that the enormous use of this system of construction in such cases calls for a most careful consideration by your board of the question. Should you so desire we shall be pleased to lay before you in detail our experience and knowledge in regard to it.

We would also respectfully submit that your present attitude in giving a period of thirty years for the repayment of a loan on work in concrete or steel not in combination, in which the steel requires for preservation a frequent renewal of the painting (which it may or may not get), and in giving only one-half that period for concrete and steel in combination, in which the steel is preserved by the concrete—the best-known preservation, and one not requiring renewal—cannot but appear inconsistent to all who are concerned in this matter.

So far as the preservation of the reinforcements is concerned, there can be no doubt that the imbedding of steel in Portland cement concrete is the very best means of preserving the steel from oxidation. Experience in the use of such concrete for coating the interior of steel ships, for encasing anchor chains and cables of suspension bridges, for surrounding the holding-down bolts for heavy engine foundations and other similar purposes, the results of laboratorial and practical experiments, and the observations made on structures of many kinds, have proved beyond doubt that steel embedded in dense concrete, such as is essential for reinforced concrete works, will be preserved in perfect condition for an almost unlimited period.

With respect to the effects of fire on reinforced concrete structures, the results of actual fires and the tests carried out by the British Fire-Prevention Committee have shown that with adequate covering of the steel and the use of suitable concrete aggregates structures of reinforced concrete retain practically their full resistance to imposed stress after being subjected to high temperatures.

Reinforced concrete is specially adapted to the resistance of shocks and vibration, and the effects on the structures of this material which passed through the earthquakes at San Francisco and Kingstown (Jamaica) have shown this to be the case.

Numerous experiments, some of which have been carried out on actual buildings, have demonstrated that unmistakable signs of failure will show themselves in properly-designed reinforced concrete structures long before any collapse can occur.

In our opinion, if a structure in this material is properly designed and constructed, no premature failure can occur provided that the false work is removed after a sufficient time has been allowed for the concrete to set, and if the test loading does not exceed the limit adopted for steel structures.

Reinforced concrete has proved an eminently satisfactory and economical material for structures such as sewers, pipes, and reservoirs when the concrete is of a dense nature.

The cause of most of the failures which have occurred can be traced to carelessness in construction, the use of improper materials, the premature striking of the false work or the application of an excessive test load prior to the structure attaining its full strength, and we may confidently assert that no failure has occurred which can in any way be considered as being due to the inherent unsuitability of the material.

The suitability and economy of reinforced concrete for engineering and architectural structures is borne out by its employment on the most extensive scale by Government departments and railway, dock and other companies. These departments and companies would not so construct these works unless satisfied they were of similarly permanent character to those of brick or stone, nor would they use a material which might prove dangerous or liable to failure. Further, we would point out to you that the Royal Institute of British Architects recently appointed a committee of engineers and architects to report on reinforced concrete structures, who unanimously advised that under proper conditions, such as are required in all works, there is no reason to fear want of durability.

We should mention that the recommendations of the committee appointed by the Royal Institute of British Architects as to reinforced concrete are those that are acted upon in up-to-date practice, and that reinforced concrete executed in accordance with these rules is the reinforced concrete for which loans should be approved.

To keep our memorandum within short compass, we have limited ourselves to a general treatment of the subject, and have not dealt with individual instances which would bear out our contentions, but we respectfully submit that if your board is not satisfied with the representations made by us they should make a thorough inquiry into the question at which detailed evidence could be given of the durability of such work, and the opinions of those with practical experience in its use brought before you.

I have the honour to be, Sir,
Your obedient servant,
THOMAS COLE.

11 Victoria Street, S.W.
July, 1908.

THE following engineers and architects served on the special committee which had the subject of the foregoing memorandum under consideration, and we give the names in alphabetical order—viz.: Messrs. W. Armstrong, M.Inst.C.E. (engineer for new works, Great Western Railway), J. A. Brodie, M.Eng., Wh.Sc., M.Inst.C.E. (City Engineer of Liverpool), A. E. Collins, M.Inst.C.E. (City Engineer of Norwich), J. W. Cockrill, M.Inst.C.E. (Borough Engineer of Great Yarmouth), W. Dunn, F.R.I.B.A., C. F. Marsh, M.Inst.C.E. (Metropolitan Water Board), C. S. Meik, M.Inst.C.E., J. S. Pickering, M.Inst.C.E. (Borough Engineer of Cheltenham), Edwin O. Sachs, F.R.S.Ed., M.I.Mech.E. (Chairman, British Fire-Prevention Committee), and H. D. Searles-Wood, F.R.I.B.A. (Chairman, Royal Sanitary Institute).

THE INTERNATIONAL COMMISSION ON REINFORCED CONCRETE.

WE have last year referred to the constitution of this important commission, which should do much to standardise the practice of reinforced concrete, and above all be able to give the technical professions of all countries a precise and reliable summary of the experience in the principal countries of Europe and the United States. It is exceptional to find an international commission such as this one, so entirely constituted of what we would term workers, who are practically the leaders of investigation as far as it affects constructional matters, and it is a matter of congratulation that their energies are to be devoted to the subject under review.

When the Commission was constituted in 1906, reinforced concrete by no means played such an important *rôle* as it plays in this country to-day, and this is probably the reason that we find only two British members on the Commission as against the larger number from Germany, France, Russia, and Austria. This matter, we understand, will, however, be shortly remedied at the suggestion of

Mr. Edwin O. Sachs, F.R.S.Ed., who, as a member of the Commission, has proposed that the newly-formed Concrete Institute of this country should be represented, and also, if possible, one of our public departments. We understand that the necessary steps are being taken in this direction.

THE MEMBERS OF THE COMMISSION.

The Commission, as it stands at present, has for its chairman the well-known and eminent authority, Professor Schüle, Director of the Testing Station of the Zürich Polytechnic, whilst its vice-presidents are Professor A. N. Talbot, of the University of Illinois, U.S.A., and Privy Councillor Germelmann, of the Ministry of Public Works at Berlin.

The other members of the Commission named in alphabetical order are as follows :—

Professor Abramoff, St. Petersburg.
*Herr Bürstenbinder, Building Police Surveyor, Hamburg.
*Professor N. Belelubsky, Director of the Technical Laboratories, St. Petersburg.
Mr. Bogouslawsky, St. Petersburg.
Herr Victor Brausewetter, Engineer, Vienna.
Mr. Max Clarke, Vice-Chairman, Science Committee of the R.I.B.A., London.
Mons. P. Christophe, Principal Engineer, Office of Works, Brussels.
*Professor S. Canevazzi, Engineering School, Bologna.
Professor A. Czako, Budapest.
*Monsieur Considère (until lately an Inspector-General of Public Works in France).
Monsieur Droujinine, Polytechnic Institute, St. Petersburg.
*Dr. von Emperger, Editor of "Beton und Eisen," Vienna.
*Monsieur Féret, Chief of the Technical Laboratories, Boulogne.
Captain T. Grut, Military Engineer, Copenhagen.
Professor C. Guidi, Engineering School, Turin.
*Herr A. Hüser, Civil Engineer, Germany.
Colonel Jitkewitsch, St. Petersburg.
*Professor B. Kirsch, Royal Technical College, Vienna.
*Monsieur R. Maillart, Zürich.
*Dr. A. Martens, Principal of the Prussian Testing Laboratories, Berlin.
*Professor J. Melan, Royal Technical College, Prague.
*Professor Mesnager, Director of the Technical Laboratories, Paris.
Professor Desiderius Nagy, Royal Technical College, Budapest.
Professor Samuel Pecz, Royal Technical College, Budapest.
*Monsieur Rabut, Engineer to the Office of Works, France.
*Monsieur S. J. Rutgers, Municipal Engineer, Rotterdam.
*Mr. Edwin O. Sachs, British Fire-Prevention Committee, London.
*Professor E. Suenson, Royal Technical College, Copenhagen.
*Monsieur J. Schustler, Budapest.
Signor C. Segré, Chief Engineer to the Railway Testing Laboratories, Rome.
Monsieur Tricon, of the Reinforced Contractors' Society, Paris.
Professor F. R. Turneaure, College of Mechanics, Wisconsin, U.S.A.
Professor W. H. Warren, University, Sydney.
Herr E. Züblin, Civil Engineer, Strasburg.
Dr. R. Zielinski, Tutor at the Royal Technical College, Budapest.
The Principal of the Highways Office, Christiania, with *Mr. Ernst Reitler (Vienna) as Secretary.

It may be recollected that the first president of the Commission was Monsieur Considère, but he very naturally laid down this office upon his retiring from the post of Inspector-General of Public Works in France and taking up the industrial aspect of reinforced concrete. His valuable co-operation has, however, been retained as an ordinary member of the Commission.

THE COMMISSION'S MEETING AT BÂLE.

The meeting which took place at Bâle last month, and at which Professor Schüle presided, was attended by Privy Councillor Germelmann and those members whose names have an asterisk in the list above. It was an important one, inasmuch as it afforded an opportunity for the *personal* exchange of views and opinions as against the exchange that had heretofore been one by correspondence only. German, as it happened, was found to be a language understood practically by all present, and the discussion was thus very greatly facilitated.

The purely technical character of the meeting too, without the interruptions of the usual banquets and the like, was a great improvement upon what is generally met with at meetings of other commissions. The members simply lunched and dined together, and were quartered at the same hotel, and there was little ceremony.

THE COMMISSION'S PROGRAMME OF WORK.

As to the more immediate programme of work, we think we can do no better than present a summary of a memorandum laid on the table by Professor Schüle. It read as follows :—

> The application of reinforced concrete to all kinds of work in connection with engineering and architecture has caused quite a number of technical questions to be raised—some of them of a very complex character—as to the safety and life of structures of this material.
>
> In its early days, reinforced concrete—comprising materials of such an utterly different character as iron and concrete—cannot be said to have been very favourably received by those who occupied themselves with the scientific aspects of building construction, and thus at the International Congress on the Testing of Materials, held at Budapesth in 1901, reinforced concrete was but very casually mentioned in a short note by Monsieur Considère. Since that time, however, numerous buildings in reinforced concrete have been erected, and much experience has been gained in the different countries, and the scientific aspects of reinforced concrete have become matters of moment to all concerned.
>
> It was in France that the initiative was taken of investigating reinforced concrete systematically. A French Commission of Inquiry was formed by a Ministerial Order of December, 1900, which undertook a series of experiments, and this investigation resulted in the Report of October 20th, 1906, which contained instructions regarding the use of reinforced concrete pending further experience being gained. (See "Concrete," Vol. I., Nos. 5 and 6.)
>
> Other countries also realised the importance of having some rules or recommendations upon which to base the calculation and execution of works in reinforced concrete, and the following method was generally adopted by the different nations concerned—namely : (1) Provisional Rules were set up by the most competent and experienced public officials or professional men conversant with the work ; (2) National Commissions were created to pursue the studies and elucidate technical points. The expenses incurred by these technical commissions are either borne by the State or by funds subscribed by the industries concerned, or by both.
>
> In Germany and in the United States the research work is being carried out on a vast scale, and large sums of money are expended on it. In fact, a majority of the testing laboratories all over the world, but especially in the United States and Germany, have occupied themselves for some years so actively with experiments in reinforced concrete, that one can say with truth that at no period have there been such a number of engineers working to progress a branch of civil engineering as is the case at present with reinforced concrete.
>
> The International Congress of Testing Materials, held at Brussels in 1907, recognised the great international importance of reinforced concrete, and thus arose the constitution of the International Commission on Reinforced Concrete, the study of reinforced concrete on international lines.
>
> Monsieur Considère, who, prior to his retiring from the official position he held in France, occupied the chair in this Commission, issued a memorandum to the members in which he proposed a number of questions to be dealt with, embracing all points relating to the constitution of reinforced concrete as distinct from its application. He proposed as a preliminary the preparation and consideration of :—
>
> A.—A summary of tests completed in different countries.
>
> B.—A summary of the facts definitely established by these tests.
>
> C.—A summary of the chief causes of difference of opinion on questions relating to reinforced concrete.
>
> D.—A set of standards for future tests.
>
> There can be no doubt that this programme, if put into execution, would make a considerable difference in the science of reinforced concrete ; but, as I mentioned in my memorandum when appointed to the chair, upon Monsieur Considère's resignation, the research work at present in train is not sufficiently advanced to permit of data being collated in time for the next International Congress on Testing Materials, to be held at Copenhagen next year, and we must limit our work to some preliminary matters for the present until we meet again at Copenhagen next year.

As to the more immediate action to be taken, a resolution to collate the existing data as to tests executed or in hand from all countries, and to present them in time for the next meeting at Copenhagen in September, 1909, is one upon which the Commission deserves congratulation, for nothing at the moment exists in tabulated form from which information can be obtained of a reliable character.

Of sub-committees formed, one which will deal with the question of calculations and algebraical formulæ and an international system of notation claims attention, and it is to this sub-committee that will also be entrusted the work of advising the Commission as to standard forms of tests.

Altogether, the constitution of this international commission should be a matter of great value to all interested in reinforced concrete, and the Commission has the best wishes of this journal, for what we realise must be a laborious undertaking for many years to come.

CONCRETE FOR ROADS.

THE International Road Congress, which was held at Paris last month, will probably lead to the constitution of a Central Bureau for the exchange of experience relating to matters of road construction.

It is pleasant to observe that at this Congress far greater attention was accorded to the quality of materials used in road-making than could have been expected a few years back, that road surveyors are gradually realising the high importance of the selection of their materials, and gradually both they and the authorities for whom they work have found that it does not pay to accept any material of an inferior kind, and particularly not the poorer qualities of Portland cement.

For roads having hard wear nothing is more important than the quality of the Portland cement used in the concrete foundation, and it is extraordinary that there should be still road authorities who actually specify a second or third quality of Portland cement, instead of a Portland cement that has passed the British Standard Specification.

When referring to concrete for road-making we have, of course, in mind the foundation for the road surface only, but there are also signs at the Congress that the question of the road surfaces in concrete and reinforced concrete will soon be having the serious consideration of those concerned, and that reinforced concrete roads of special hard and grooved surface may be expected in the near future for the motor tracks and also for high roads.

Altogether those interested in concrete would do well to carefully watch the development of modern road-making and the work of the bureau to be instituted by the Road Congress.

THE LATE SIR EYRE MASSEY SHAW AND CONCRETE.

FEW can realise that much that is common practice to-day was long a matter of prognostication on the part of the late Sir Eyre Massey Shaw when he had command of the London Fire Brigade some thirty years ago. He fully realised the advantages of concrete as a fire resistant, and appreciated its qualities in particular as a protective covering for metal work.

He was a quarter of a century before his time in the advocacy of better fire-resisting construction, but it is pleasant to those who knew him to read his older writings and see how closely his views have been acted upon to-day.

His great bugbear was the so-called "fireproof" building, in which incombustible materials, such as metal, were supposed to afford fire resistance, although in no way protected by concrete or similar covering. The false application of the term "fireproof" to such structures was the subject of many of his most energetic sayings and writings.

He was also one of the first to realise the different standards of fire resistance necessary for different classes of buildings.

Although now for many years not participating actively in matters relating to fire prevention, there can be no doubt that many of the useful facts as to fire resistance which he put forward during his successful reign as Chief of the London Fire Brigade will still long serve as a guide for those engaged in the application of concrete and constructional engineering.

THE PORTLAND CEMENT INDUSTRY.

THE annual address of the chairman of the Associated Portland Cement Manufacturers, Ltd., Mr. F. A. White, generally contains a useful summary as to the application of Portland cement to modern structural purposes in this country.

There can be no doubt that any increased application of concrete and reinforced concrete must favourably affect the producers of Portland cement, and that when this country again enjoys normal conditions of trade, and an average activity in the building trade in particular, the great advance made in the application of these materials must mean a greater production of Portland cement. Were it not, in fact, for the great advance in the uses of concrete during the last few years, many of the manufacturers at present producing cement would have a far smaller output of their product than was the case this year.

Some expressions from the chairman's speech are given below as being of general interest, but there is one point that we would still mention that is not contained in the summary presented, and is of technical importance. Mr. White referred to the decrease of imports from abroad, which, in other words, means that the British user of Portland cement is at last beginning to properly realise the dangers of the substitutes, such as natural cement, or adulterated "Portland" cement, which some years back found their way into the British market, in very large quantities, and, what is more, very frequently under false labels. The decrease in the importation of foreign cement is most satisfactory.

Note should be taken of our quotation of the remarks made as to the relations between cement makers and the technical professions. It is an important matter that the professions should have a full knowledge of what the cement maker aspires to and attains in his product, and the company over which Mr. White presides have done well to inspire the confidence of the engineer and architect by throwing open the gates of their works and encouraging inspection.

Portland Cement and the Technical Professions.

IT has been our policy to keep in touch with various societies of engineers and architects and users of cement in England. The day has gone by when such a manufacture as ours is treated as a secret to be over-jealously guarded, especially as against those who are not competitors, but our best supporters. Our trade is looked upon as an important one by the members of these professions. We depend upon their goodwill, and we value their confidence, and, therefore, from time to time parties of them arrange to visit our works, and thus form a closer acquaintance than they would otherwise possess with our methods of manufacture and of business. Students of the Institute of Civil Engineers have also paid us visits. The result is that those who are now, and those who are likely to become, directly or indirectly large users of cement in their various enterprises realise more and more the advantage of dealing with a company whose methods are of the latest, and whose scale of operations is adequate for meeting their largest requirements. It is satisfactory, too, to note that imports of cement from abroad have now descended to about the level that they occupied before the Company was formed, that our contracts for sales ahead at the close of this financial year were of average tonnage, which is very large, and that, whatever may be the reasons for some temporary slackness in the world's consumption of cement, there is nothing to show that it is due to any less appreciation of it as a material for construction. On the contrary, it seems to do nothing but grow in favour.

Portland Cement and Reinforced Concrete.

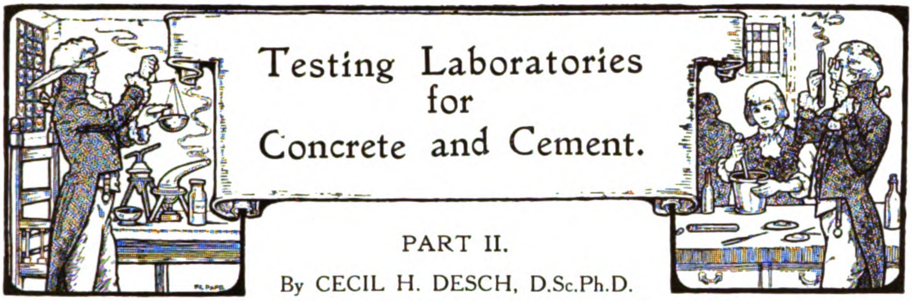
Its use for reinforced concrete increases, and seems likely to increase. A very marked impetus will probably be given to it in the near future by the adoption of proposals which have been made for the amendment of the by-laws under the Building Acts, some of which have been a hindrance to the development of concrete construction. What is also most important is its growing employment by Government Departments, Railway, Harbour and Dock Boards, and by an increasing number of municipal bodies. We have ourselves afforded an object lesson by building the large new wharf and jetty at Swanscombe, which we were obliged to have, in this manner, and we hope that when it is finished it will lead many to follow our example. It may interest you to know that this reinforced concrete is in fact beginning to be called the "industry of the future." It is in some cases the main material employed in the whole building. I may give you a few instances. Not only is the new General Post Office being built of it, but also several district post-offices in London and in provincial centres. Another instance is the Great Central telegraph stores at Birmingham. Following the example of the Manchester Ship Canal Board, the Avonmouth Dock authorities at Cardiff, and those of the Sandon Dock in Liverpool, have put up large warehouses and sheds in the material, and the South-Western Railway, the Great Western Railway and the North-Eastern Railway have used it in important structures. All over the country a large number of factories, warehouses and workshops are being erected in reinforced concrete, amongst them the great works for the Aluminium Company in Scotland. The example of what is being done at home is being followed in some of the colonies to which we send Portland cement. You will readily believe that in these circumstances the Institution of Civil Engineers, the Royal Institute of British Architects, the British Fire Prevention Committee, and the Association of Municipal Engineers are taking great interest in the subject. The last-named body has, in fact, been taking up the question of loan periods to local authorities in connection with reinforced concrete works, a matter upon which, as I told you last year, municipal engineers had a serious grievance on account of the illogical obstacles put in their way by the Local Government Board, who have limited the loan periods in these cases to about 15 years, as against 30 years in the case of brick buildings. The Press, too, has given much attention to the advancement of this building material.

Growing Need for Portland Cement.

Nor is its use confined to such permanent, stationary structures as these; sewage pipes of all diameters have been largely made in it, especially on the Continent. For railway sleepers its durability and moderate cost are bringing it into favour. Telegraph and telephone poles are among its most recent applications, and its employment instead of timber for these and for fence posts may well develop. Even the homely washtub is being made of it. Ships are not only coated with cement internally, as has long been the custom, but river craft are actually being laid down in reinforced concrete, while the increasing size of war vessels is calling for larger docks, many of which are projected and will doubtless be built in this material. All this points to the growing need for Portland cement in every quarter of the globe, and it is an interesting fact that in Germany statisticians have already begun to record in terms of the population tonnage of cement produced, as is done for beer and spirits. May the day soon come when we can speak of an output of a ton of cement per head of the population of Great Britain and the colonies. A cask per head in the British Isles would probably more than double the present output.

THE CONCRETE INSTITUTE.

In further reference to the Concrete Institute that was formed this year, and of which the Earl of Plymouth, C.B., is the President, we are pleased to hear that its membership is rapidly increasing, and that it now already exceeds 300. We are also pleased to hear that a very large majority of the members are members or associates of the Institution of Civil Engineers, which is an excellent indication of the interest now taken in the subject of concrete and reinforced concrete in professional circles. The offices of the Concrete Institute are at 1 Waterloo Place, London, S.W., to which address communications should be addressed to Mr. A. E. Collins, M.Inst.C.E., the General Honorary Secretary. The second Council meeting of the Institute took place last month. The first paper to be presented during the autumn session will be by the well-known authority on reinforced concrete, Mr. Marsh, M.Inst.C.E., who will, however, be dealing with the subject of concrete generally.



Testing Laboratories for Concrete and Cement.

PART II.

By CECIL H. DESCH, D.Sc.Ph.D.

The absence of an official laboratory devoted to investigations with concrete and cement may be said to account in no small degree for the dearth of reliable data as to reinforced concrete as designed and executed in this country.

Some testing station enjoying official support, or if conducted as a private enterprise enjoying the reputation of absolute reliability, would be very much in place at the moment, and it might be a matter worthy of the attention of the Concrete Institute to consider the possibility, and ways and means of obtaining for the British Empire some laboratory of this description.—ED.

In the first article of this series a general sketch of the equipment required in a laboratory devoted to the investigation and testing of cement and concrete was given. Subsequent articles will describe the actual equipment of some of the principal laboratories and testing institutions on the Continent and in the United States. The present article gives some account of three representative laboratories in this country, two of which are maintained by leading manufacturers of Portland cement, and the third by a firm of contractors largely engaged in reinforced concrete construction.

The Associated Portland Cement Manufacturers, Ltd., have established chemical and mechanical laboratories at their Works Offices, at Park House, Gravesend. Our first illustration (*Fig.* 1) shows the chemical laboratory, which accommodates 13 or 14 chemists, and is well equipped with furnaces, draught-cupboards, electrically driven stirring gear, etc. A large part of the work here naturally consists of the analysis of cement clinker and of the raw materials used in manufacturing cement. Both the Bamber water-

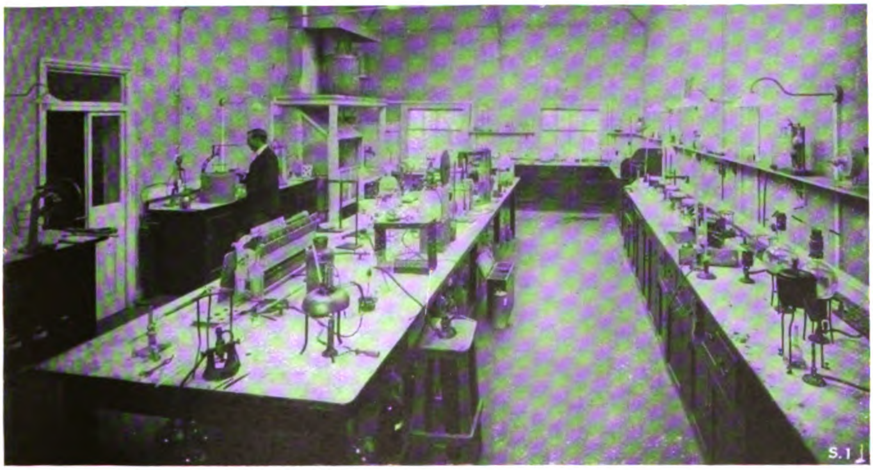


Fig. 1.

jacketed and the Slater types of calcimeter are used in the estimation of calcium carbonate. Fuel analysis is another important item, and in determining the calorific value of fuels the Mahler bomb is found to give the

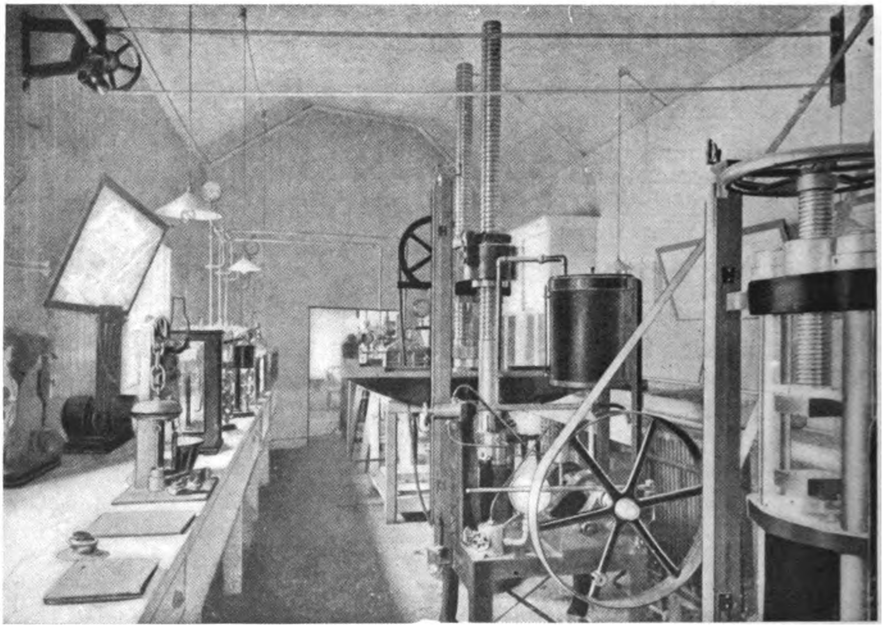


FIG. 5.

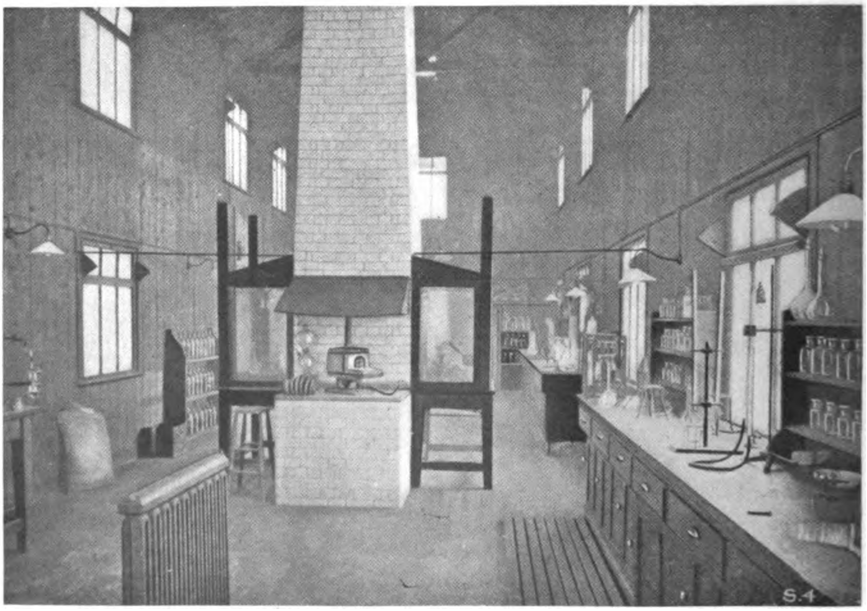


FIG. 3.

most accurate results. A separate room, maintained at constant temperature, is provided for its accommodation. The high temperature necessary for making experimental batches of Portland cement clinker is obtained by means of furnaces supplied with an oxygen blast.

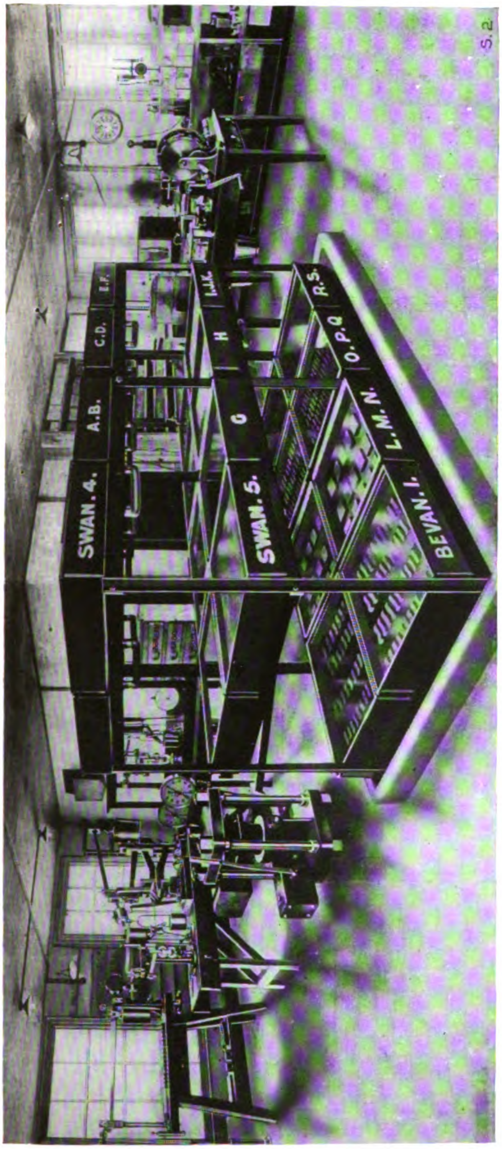


Fig. 2.

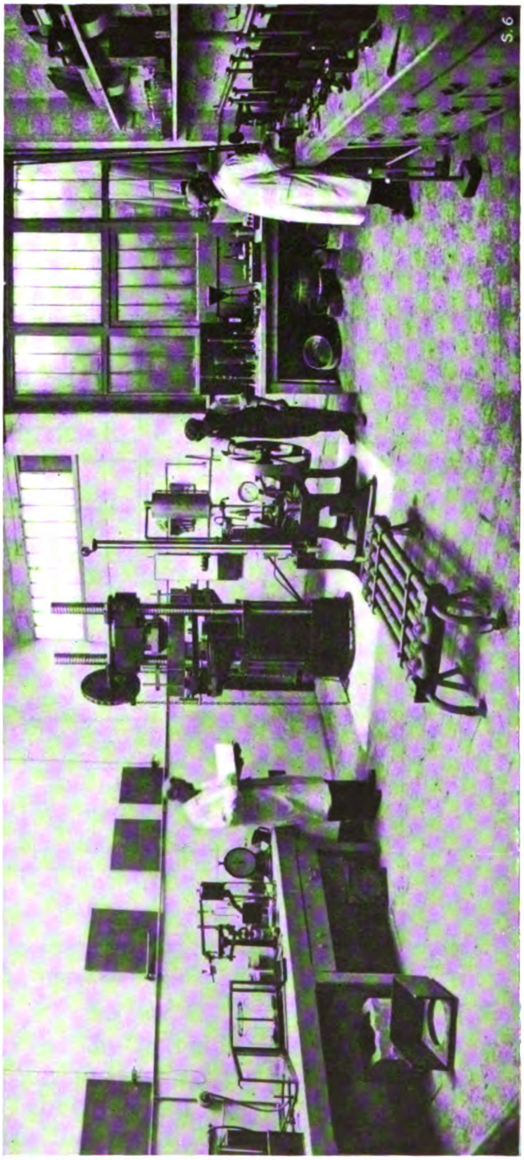


Fig. 6.

Oil tests are naturally of importance in large works, and the requisite flash-point and viscosity apparatus is therefore provided. Temperatures and barometric pressures are registered by means of automatic recording instruments. There is no need to describe in detail the remaining equipment, which is designed both for routine work and for investigation.

The department for physical and mechanical tests contains, in addition to a number of tensile machines of different types, a compound lever 42-ton compression machine taking cubes up to $2\frac{3}{4}$ in., and a 250-ton hydraulic machine taking cubes up to 9 in., the last-mentioned machine being used for testing the influence of the proportions and nature of aggregate on the strength of concrete. *Fig.* 2 is a photograph of this part of the laboratory, and shows in the foreground the tanks, kept by means of circulating water at a constant temperature, in which hardening takes place. There are also various forms of apparatus for carrying out accelerated tests for expansion, and a separate room, maintained in a constant hygroscopic state, is reserved for making tests of setting time. Expansion and the depth of needle impressions are measured with the aid of micrometers. Another feature in the equipment is the provision of an apparatus for measuring percolation.

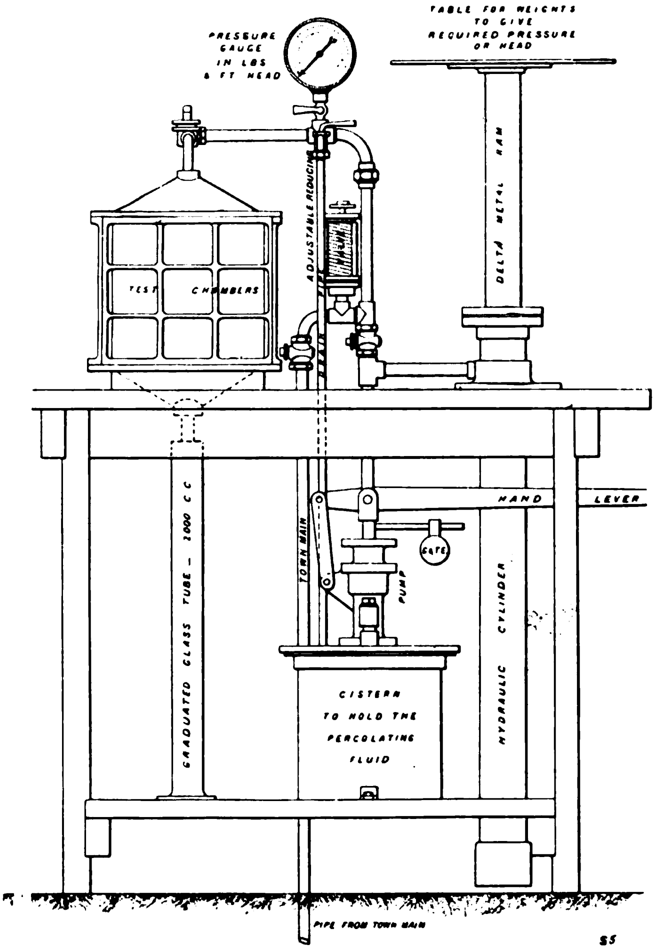

PRESSURE GAUGE IN LBS & FT HEAD
TABLE FOR WEIGHTS TO GIVE REQUIRED PRESSURE OR HEAD
TEST CHAMBERS
ADJUSTABLE REDUCING
DELTA METAL RAM
TOWN MAIN
HAND LEVER
SAFE
PUMP
GRADUATED GLASS TUBE - 2000 C C
HYDRAULIC CYLINDER
CISTERN TO HOLD THE PERCOLATING FLUID
PIPE FROM TOWN MAIN
SS

FIG. 4.

The second installation to be noticed is that of Messrs. G. and T. Earle, Ltd., of Wilmington, Hull, in the designing of which great assistance was given by Mr. Herbert Anderson, of Kingston. The chemical laboratory, represented in *Fig.* 3, and rooms attached to it, are equipped for the full analysis of cement and raw materials, fuel, and kiln and flue gases.

In the mechanical laboratory, table shot machines are used for breaking tensile briquettes or small prisms, tested transversely. The same machines can also be adapted to make two other kinds of tests, one for the adherence of freshly made cement blocks to a hardened surface, the other for the penetration of a Vicat needle into lime mortar, plaster or asphalt. Tests on neat cement briquettes over 30 days old require a heavier machine, and for this purpose a 1-ton Adie steelyard machine is employed. Percolation tests are made in a specially designed apparatus, illustrated in *Fig.* 4, capable of taking blocks of 1 cub. ft., and used for comparing different aggregates, etc. All cement-sand briquettes are automatically rammed by means of a Boehme machine, and sand compression cubes by the Webb hammer, ensuring the uniform ramming of each specimen. There are two machines for compression tests, both hydraulic, and made by Messrs. Amsler-Laffon & Sons, of Schaffhausen. The smaller, up to 30 tons, takes the usual cubes of mortar; the larger is a 200-ton press, capable of taking beams, arches or girders, as well as concrete cubes. The construction is similar to that of the 150-ton press by the same makers, shown in *Fig.* 7. The wearing power of concrete surfaces is tested with the sand blast and with an abrasion machine.

The Le Chatelier test is used for determining soundness, but in addition to this the expansion of specimens kept for long periods under different conditions is measured by means of a Bauschinger micrometer. A feature of the equipment is the extensive provision for storage. Besides the week and month tensile tests, which have to be stored until the time for testing them arrives, knife-edge pats and Le Chatelier cylinders are kept in pigeonholes for five years after the date of manufacture, and a glass tube of each lot of cement is kept for seven years. The general arrangement of some of the testing machines is shown in *Fig.* 5. In the photo-micrographic room, clinker, briquettes, sand and residues are examined, and the results can be shown on a screen by means of a projection apparatus.

The laboratory of Messrs. Wm. Cubitt & Co., of Gray's Inn Road, W.C., is intended for the purpose of controlling the quality of the cement supplied to them, and of testing concrete. One side of the laboratory is shown in *Fig.* 6. Besides the usual test of fineness by means of mechanical sieves, each consignment of cement is examined for its litre-weight or "apparent density," to which considerable importance is attached. The Le Chatelier test is used, in accordance with the usual practice in this country, for detecting expansion. The table shot machine is generally used for tensile tests, although there is also a large one of the steelyard pattern. The hydraulic 150-ton testing machine, with rotary pump, was constructed by Messrs. Amsler-Laffon & Sons, and is suitable either for crushing concrete blocks or for transverse tests on plain or reinforced concrete beams or slabs. The iron moulds and rammers for making 4-in. and 6-in. concrete cubes are seen on the right of the photograph. The arrangement of the press, when set up for transverse tests on beams, is seen in *Fig.* 7, which represents a concrete beam, reinforced with steel rods with split ends, at the moment of fracture. The pumps and cylinders are filled with castor oil, and the load is read off on a vertical mercury gauge communicating with the pump through an arrangement of pistons which reduces the pressure in a definite proportion. This type of machine is both easy and accurate in its working. Experiments of many different kinds in connection with concrete have been made in this laboratory, including some now in progress for the Concrete Aggregates Commission. The present equipment is undergoing revision, and will be added to considerably in the near future.

It will be seen from the above descriptions that private enterprise has already made considerable provision for the testing of cement, the results of which are undoubtedly to be recognised in the great improvement which has taken place in recent years, both in the quality of the English brands of Portland cement, which is now remarkably high, and in the proper proportioning of concrete. On the other hand, in spite of important researches already conducted by these firms at their own expense, provision has not yet been made for long and extensive investigations of theoretical points or comparisons of different methods, such as are carried out in the great continental testing institutions. For such a purpose, the support of public bodies or of organised associations is obviously necessary, and the subsequent articles will show the extent to which this is afforded in other countries.

In conclusion, the writer wishes to express his indebtedness to Mr. H. K. Bamber, of the Associated Portland Cement Manufacturers; to Mr. H. Earle, of Messrs. G. and T. Earle; and to Mr. B. Hannen, of Messrs. Cubitt & Co., for the information with regard to their respective laboratories, and for the use of the illustrations.

(*To be continued.*)

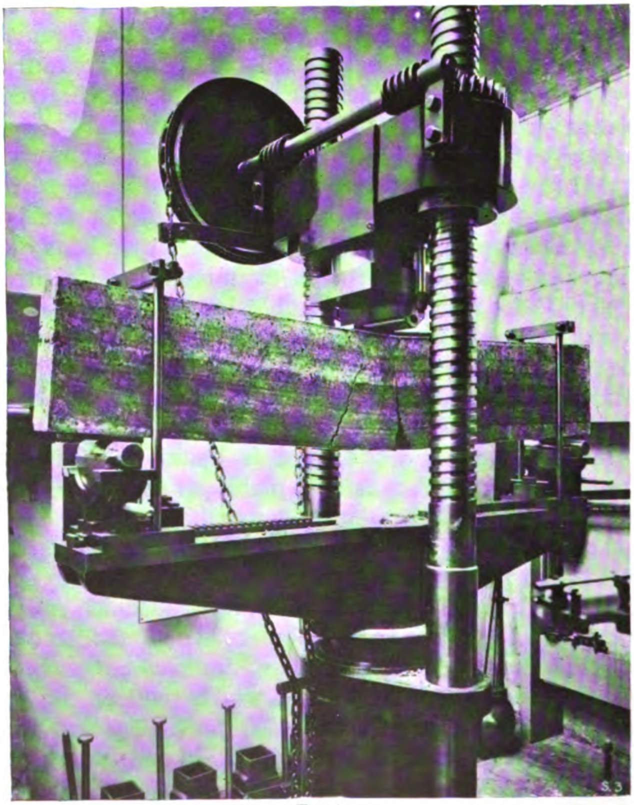
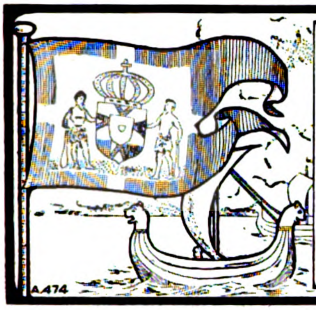


Fig. 7.



THE HISTORICAL EVOLUTION OF REINFORCED CONCRETE IN DENMARK.

By **GEORG BROHMER**, Copenhagen.

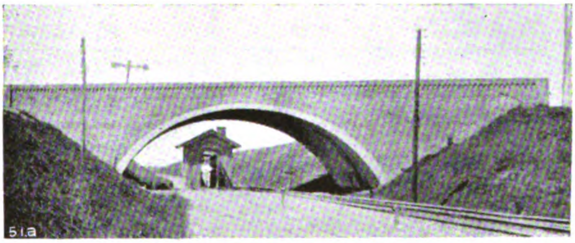
(*Translated from the Danish.*)

We have previously dealt with the Historical Evolution of Reinforced Concrete in various countries, in France, Germany, Austria, Italy, Switzerland, Holland and Hungary, and we are continuing the series by a similar article in respect to Denmark.

It is our intention to present further articles dealing with other countries, so that the series when complete may take the form of what will be practically a Universal History of the Development of Reinforced Concrete.—ED.

THE evolution of reinforced concrete in Denmark manifests similar phases of development to those which have been witnessed in a number of other countries, but more especially of late not only have works of considerable magnitude and interest been constructed within the country, but Danish engineers in this branch have invaded several of the neighbouring countries and there secured considerable influence.

Reinforced concrete has been used in Denmark since the beginning of the nineties, and from the year 1891 date several works of some importance, including the floors in the National Gallery, Copenhagen, with spans up to 9.50 m. span, and the roof of a glass works with spans of 12.50 m. span. Reinforced concrete was also used the same year for a breakwater outside the Copenhagen free harbour.



REINFORCED CONCRETE BRIDGE ON THE MONIER SYSTEM AT RUNGSTED.

During the next year or two reinforced concrete was mainly used on harbour works, but the manufacture in Denmark of Monier pipes also began about the same time, whilst the first bridge of any importance, a bridge for foot passengers with 19 m. span, just outside Copenhagen, dates from 1894. In the course of the three or four years following, however, half a dozen road bridges were built of reinforced concrete on the new East Coast railway, as also some more important bridges and other structures of different kinds for private owners.

REINFORCED CONCRETE BRIDGE ON THE MONIER SYSTEM AT KLAMPENBORG.

A number of firms are engaged in reinforced concrete work as contractors. A young firm which seems to confine itself to this speciality has pushed its way to the front during the last few years, and has done a good deal towards extending the scope for the application of reinforced concrete. This particular firm appears to be doing very well, but in other directions some of the largest contracts for reinforced concrete work have not proved so remunerative to general contractors as had been expected, a remark which more especially applies to bridge work. The contractors in Denmark generally supply the designs, and thus take the full risk in every respect, and the drawing office expenses seem to handicap their work. The cost of supervision of the materials is also found to be expensive.

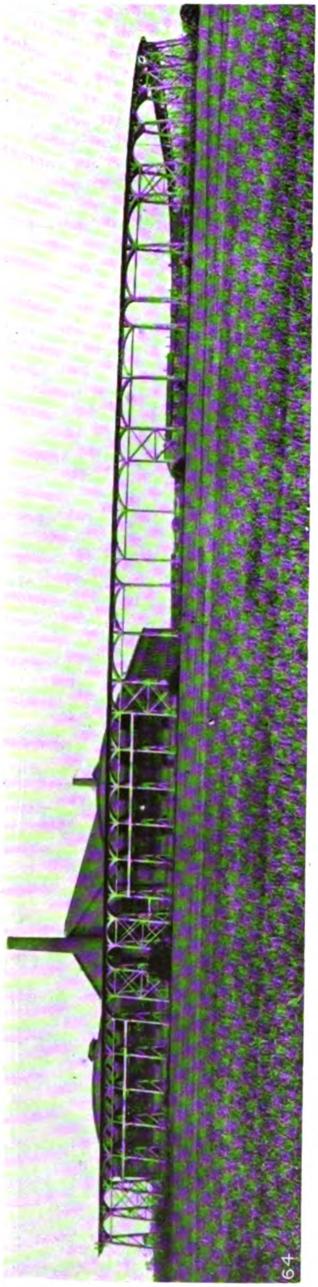
The cement used in Denmark is artificial Portland cement of good quality, which must at least comply with the specification of the Technical Society in Copenhagen. It is considered of great importance in Copenhagen for reinforced concrete work that the Portland cement used should be slow setting, six hours having been put as a minimum setting time by local experts.

REINFORCED CONCRETE BRIDGE AT VALBY.

As to steel reinforcements, an acknowledged Danish authority recommends the use of soft steel in preference to other kinds. Round rods are generally used, of which the tensile strength is expected to be 3,700 to 4,400. The Society of Danish Engineers have drawn up a model specification for soft steel for building purposes.

As to sand, a mixture of coarse and fine sand is generally recommended, and if such be unobtainable then preferably coarse grained sharp sand should be used. In Copenhagen they use a kind of sand containing a number of small stones up to ½ in. size. Sand containing clay has occasionally been used, but with most unsatisfactory results.

The concrete most frequently used in Denmark comprises Portland cement with sand and broken stone as aggregate, the stone preferred being hard and non-porous. The usual proportions of mixture are for light work from 100 of sand (including the ½ in. stone referred to above) to 50 of cement to 100 of sand to 28 of cement, but in ordinary practice the proportions are 100 of sand to 33 of cement. When broken stone is used as aggregates for rougher work the quantity of sand is, as a rule, at least half that of broken stone, often more, but the sand rarely exceeds the quantity of stone. The quantity of cement ranges between 50 and 17 per cent. of the broken stone; the proportions mostly used in Denmark are (1) 100 stone, 67 sand, 33 cement, or (2) 100 stone, 57 sand, 29 cement, or (3) 100 stone, 50 sand, 25 cement.



Reinforced Concrete Viaduct for the Municipal Gasworks at Copenhagen.

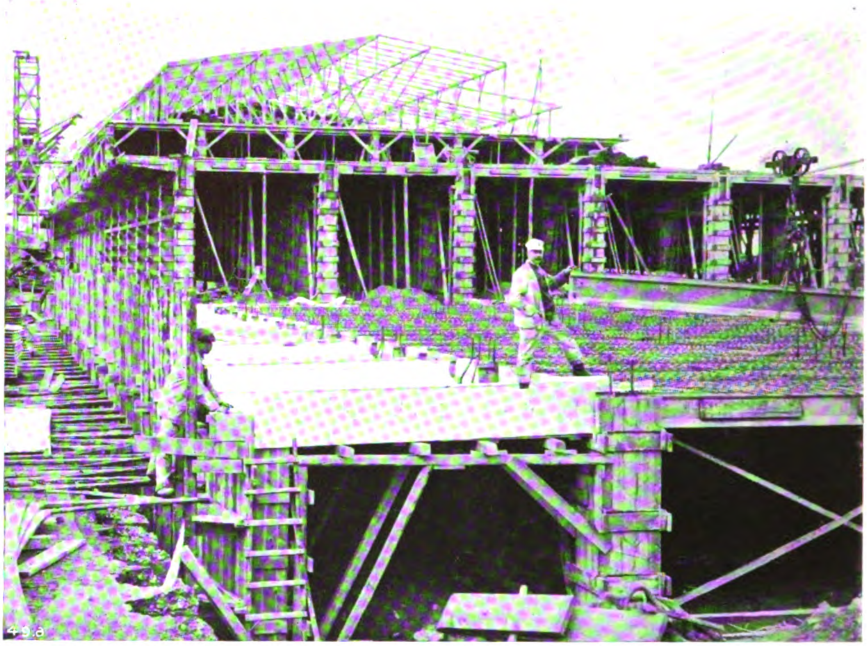
Danish advocates of reinforced concrete—and their number appears to be considerable—note with satisfaction the rapid widening of its field of utility and quote examples. Amongst the most mentioned is the viaduct for the Valby Glass Works outside Copenhagen (constructed by Carl Schiötz), which was described in our issue of May last.

Another bridge often mentioned is at Randers in Jutland (constructed by Christiani and Nielsen), where the reinforced concrete bridge has superseded an old wooden structure. This bridge has a total length of 242 ft., comprising seven bays of 34 ft. span.

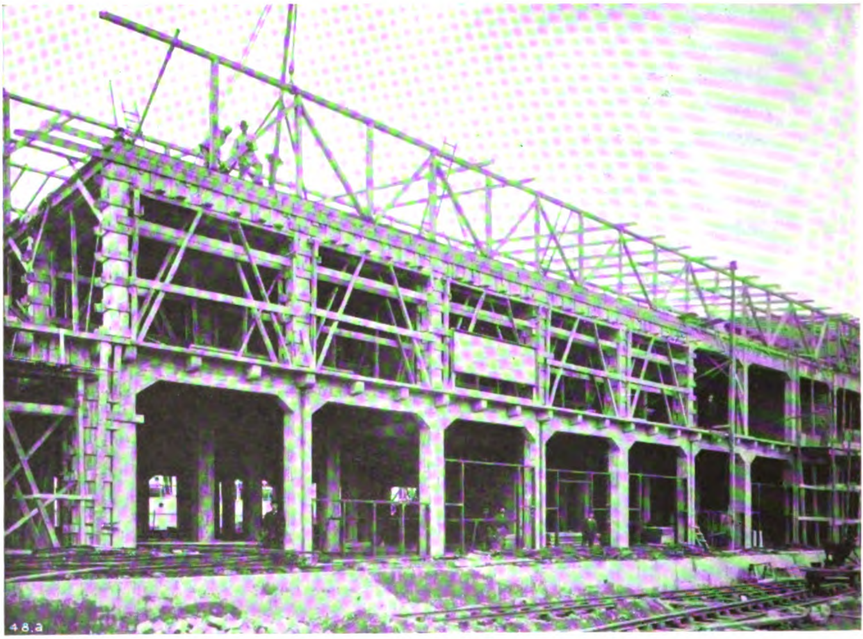
Another important reinforced concrete bridge is one in connection with the new Central Railway station in Copenhagen, under which bridge twelve railway tracks pass, with fifteen platforms. This bridge, which is built according to the Hennebique system, is 128 m. long and 195 m. broad between the railings. The foundation of this bridge consists of reinforced concrete piles, 5 m. long. The total cost of the bridge is about £15,000; an iron bridge would have cost some £5,000 to £6,000 more.

Another example often referred to is an engine-house for the shipbuilding firm of Burmeister and Wain, of Copenhagen, and a boiler-house for the same firm. The same firm has also had built a water tower at Viborg and a large bridge at Nzborg on the Visintini system 64 m. long with two spans of 24 m. and one of 16 m. (Constructed by K. Schöeler).

Denmark is one of the countries where reinforced concrete has come into almost universal use as far as the building industry is concerned, and both the State, municipal bodies, and institutions, as well as private persons, have taken kindly to it. All public buildings and factories of any importance and many private houses now at least have reinforced concrete floors, whilst not a few buildings have been built completely of reinforced concrete. One Danish firm which for years has been to the fore in this connection is that of Messrs. Emanuel Jensen and H.



Reinforced Concrete Warehouse at the Free Harbour, Copenhagen.



Reinforced Concrete Warehouse at the Free Harbour, Copenhagen.
(Constructed by Carl Schiötz.)

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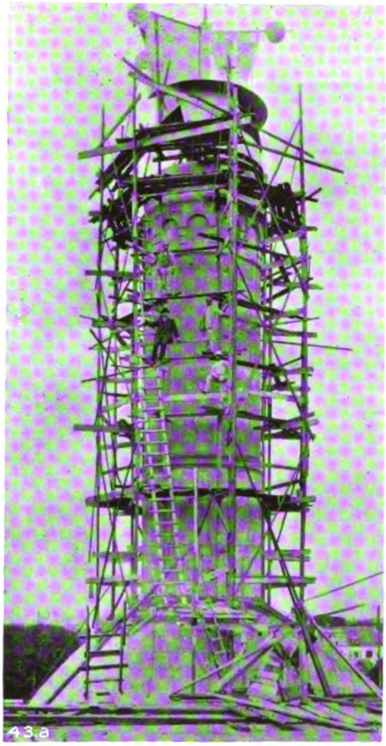
Reinforced Concrete Water Tower at Viborg.


43a

Reinforced Concrete Kiln at Tuborg Breiveries.

Schumacher, of Copenhagen, which has carried out a number of important works in reinforced concrete, both at home and abroad. This firm is at present building several warehouses at the Copenhagen free harbour of reinforced concrete, where the firm's patented "Sterile" ceilings, fireproof, reinforced concrete partitions, are being used. Instead of using round bars they have adopted pierced T sections.

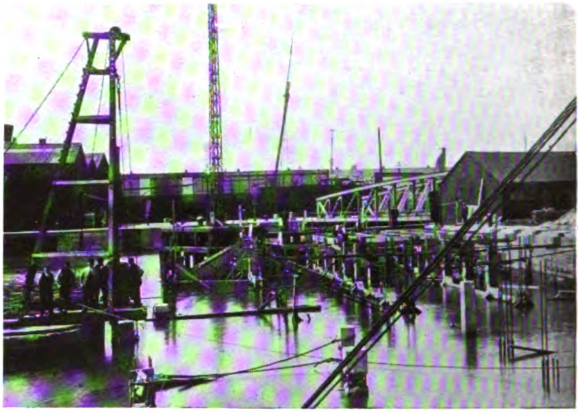
This firm has also made a speciality of poles for railings and hoardings of reinforced concrete, both rectangular, angular, and T shaped. Another interesting speciality of the firm are reinforced concrete railway sleepers, which are likely to supersede wooden sleepers in many places. This firm has successfully laid a portion of railway in China with their concrete sleepers, which are attracting a considerable amount of attention in other countries.

Reinforced Concrete Bridge at Tietgen.

NEW DOCK WORK AT LIVERPOOL.

In no type of constructional work has reinforced concrete made greater progress above ground in this country than in plain warehouse and shed work, where the leading feature of the design is being constantly repeated. Similarly there is no type of civil engineering work to which reinforced concrete can be more economically applied than to plain wharf work.

The new Liverpool Dock Works are excellent examples of what can be done in this direction.—ED.



TRANSIT SHEDS AT THE SANDON DOCK.

THE sheds on the quays of the Liverpool Docks are well known for their capacity and convenience, none but wide sheds affording large floor area per unit of length of quay being suitable for the rapid discharge of the vast quantity of goods of all sorts, of which the cargoes of the great ocean carriers consist.

The sheds may be divided generally into two types—(1) broad single-storey sheds where ample quay space is available, as in the case of some of the new docks; and (2) narrower, but still wide, sheds, having two floors, and in some cases three floors, which jointly give a floor space greater than any of the widest single-floor sheds.

The shed on the south quay of Sandon Dock, Liverpool—of which we publish illustrations in this article—is in a situation where the wide, single-storey shed is inadmissible, and the shed as constructed has two upper floors and a flat roof.

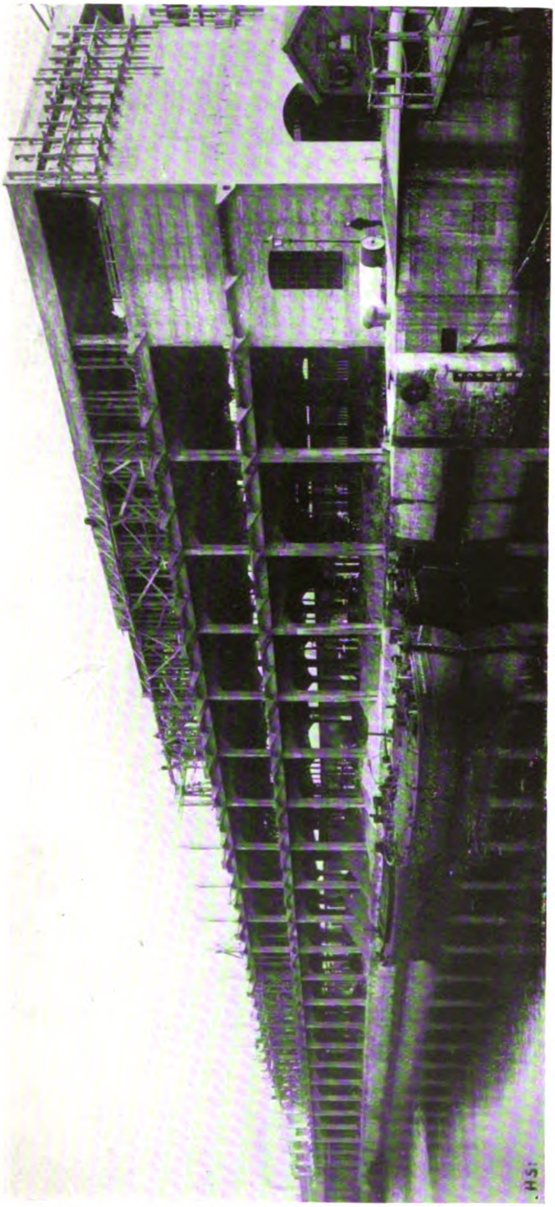
Further, in this case the usual type of brick and steel construction with slated roof has been departed from in favour of reinforced concrete, and it is noteworthy that this is the first reinforced concrete dock shed which has been constructed on the Liverpool Docks, although other dock authorities have, of course, long adopted the new material. Any backwardness in adopting reinforced concrete for sheds must, however, not be attributed to any early prejudice against this form of construction, for, as a matter of fact, on the dock estate there were pioneer works in wharves, floors, etc., in this material. It simply so happened that this was the first opportunity where all conditions, including those of price, were such as to turn the scale in favour of reinforced concrete work, as against the very economical type of brick and steel construction previously used.

Owing to consideration of roadway space, the ground floor of the new dock shed is narrower than the first and second floors, the respective widths being 78 ft. 0 in. over all for the former and 94 ft. 4 in. over all for the two latter. The result is that the upper floors and roof project over the roadway 16 ft. 4 in., being carried on cantilevers, which are continuations of the main beams.

The length of the shed as at present constructed is 628 ft. over all, to outside of end columns; this is divided into 24 bays, 22 of 26 ft. 0 in. span—centre to centre of columns—and two—one at each end—of 27 ft. 0 in. span, the half thickness of the end columns bringing the total length up to 628 ft. 0 in. Halfway along a division wall runs across all three floors.

In width the shed is divided by the rows of columns into two sections on the ground floor and three sections on the upper floors. These divisions are :—

1. The dockside section comprising half the full width of the shed, 47 ft. 2 in. from outside of dockside column to centre of centre column.
2. The ground floor roadside section, 30 ft. 10 in. from centre of centre column to outside of roadside (ground floor) columns.
3. The cantilever portion projecting 16 ft. 4 in. beyond the outside of the ground floor roadside column.


Dock Front of Shed during Construction.

THE DETAILS.

The main floor beams running across the building are continuous; they are of uniform width throughout—20 in.—and, except in the case of the cantilever carrying the first floor, of uniform depth—5 ft. 4½ in. from the upper surface of the floor.

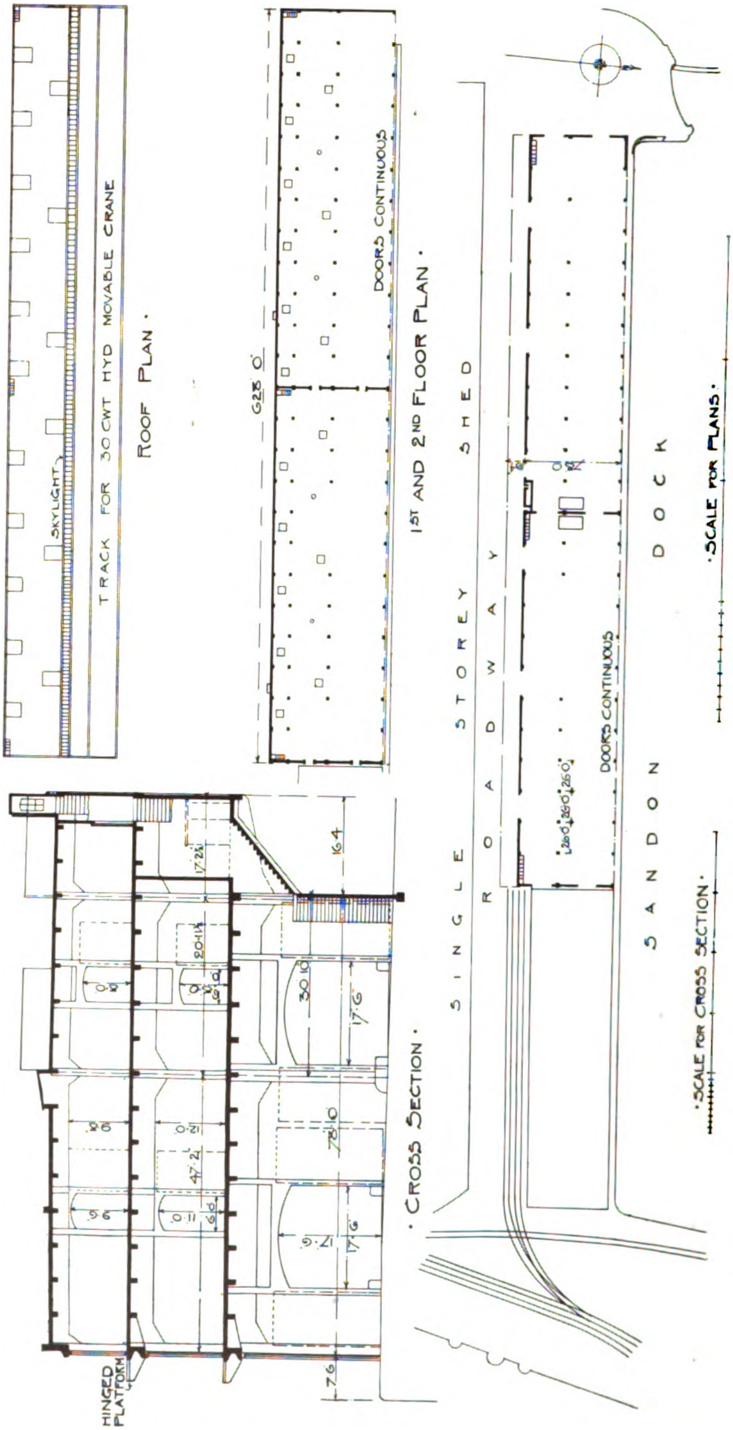
Supported by the main beams are secondary beams or "joists," spaced about 6 ft. centres, which divide the floor into 16 panels. They are 24 ft. 4 in. long between the supporting main beams. They are 8 in. wide and 20½ in. deep from top of floor.

The floor itself is 4½ in. thick, with a surface 1 in. thick of granolithic concrete.

The distributed ("live") load which the first floor is designed to carry is 25 cwt. per sq. yd. (about 311 lb. per sq. ft.).

The beams carrying the second floor and roof are of very similar character to those carrying the first floor, but being designed for a somewhat lighter live load they are of smaller dimensions as regards breadth and depth, and the reinforcement is also on a lighter scale. For the same reason the joists and floors are lighter.

The columns supporting the first floor are 21 in. by 24 in. in section, the shorter dimension being across the shed. The height of the centre columns is 22 ft. 0 in.

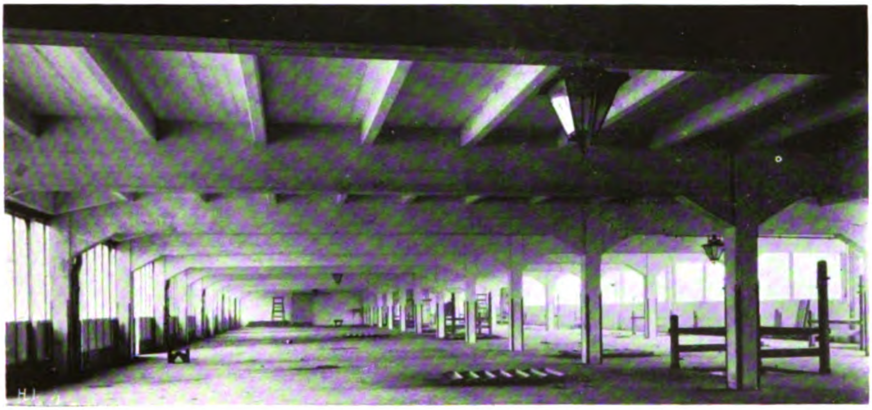

ROOF PLAN
SKYLIGHT
TRACK FOR 30 CWT HYD MOVABLE CRANE
1ST AND 2ND FLOOR PLAN
DOORS CONTINUOUS
628' 0"
SINGLE STOREY SHED
ROADWAY
SANDON DOCK
DOORS CONTINUOUS
26'0" 26'0" 26'0"
SCALE FOR PLANS
SCALE FOR CROSS SECTION
CROSS SECTION
HINGED PLATFORM
16'4
17'2½
20'1¼
30'10
17'6
78'0
47'2
17'6
17'6
7'6

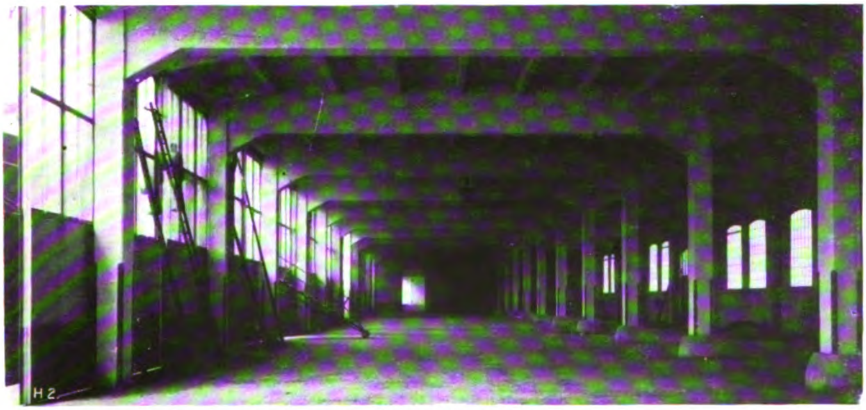
between the top of the supporting slab and the underside of the main beams which they carry. These columns are carried on groups of 5 piles each; the piles being 14 in. square in section. The upper columns are similar, but lighter.

The total weight which each of these columns and groups of piles may have to carry amounts to rather over 400 tons, that weight including both live and dead loads.

The building being entirely supported by the various columns and main beams, the walls—which in detail are similar to the floors—are of light construction, their function being merely to enclose the building.

The body of the concrete consists of screened Fleetwood gravel, Penmaenmawr chippings and Portland cement mixed in a mechanical rotary machine, and put into the work in a fairly wet state.



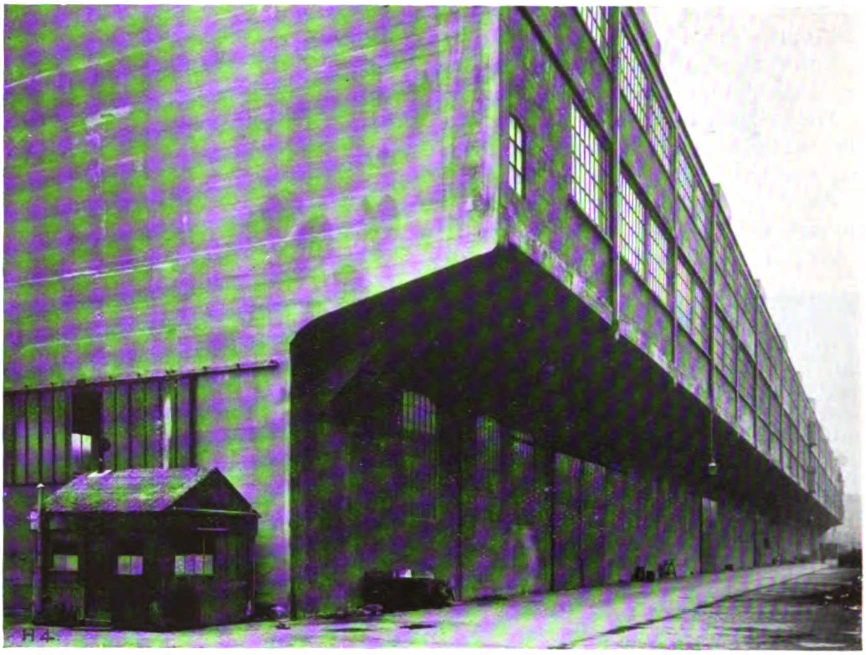


Views of Interior.

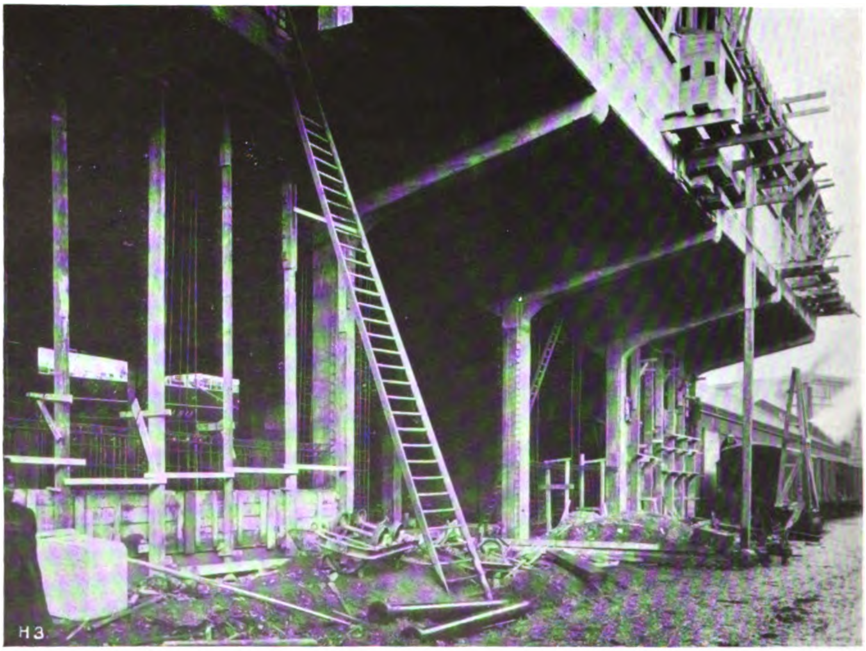
The surface of the floor—1 in. thick—was formed of granolithic concrete, consisting of two parts of crushed granite and one of cement. This was generally added while the main body of the concrete was still green.

The flat roof of the shed, in which there are openings for light, machinery, etc., is covered with asphalte $\frac{3}{4}$ in. thick.

The engineer to the works was Mr. Anthony G. Lyster, M.Inst.C.E., Engineer-in-Chief to the Mersey Docks and Harbour Board, who had the co-operation of Messrs. Mouchel and Partners, Ltd., on the reinforced concrete work, the contractors being the Liverpool Hennebique Ferro-Concrete Contracting Co., Ltd., and the system of design applied that of Messrs. Hennebique.



Roadside Front as Completed.



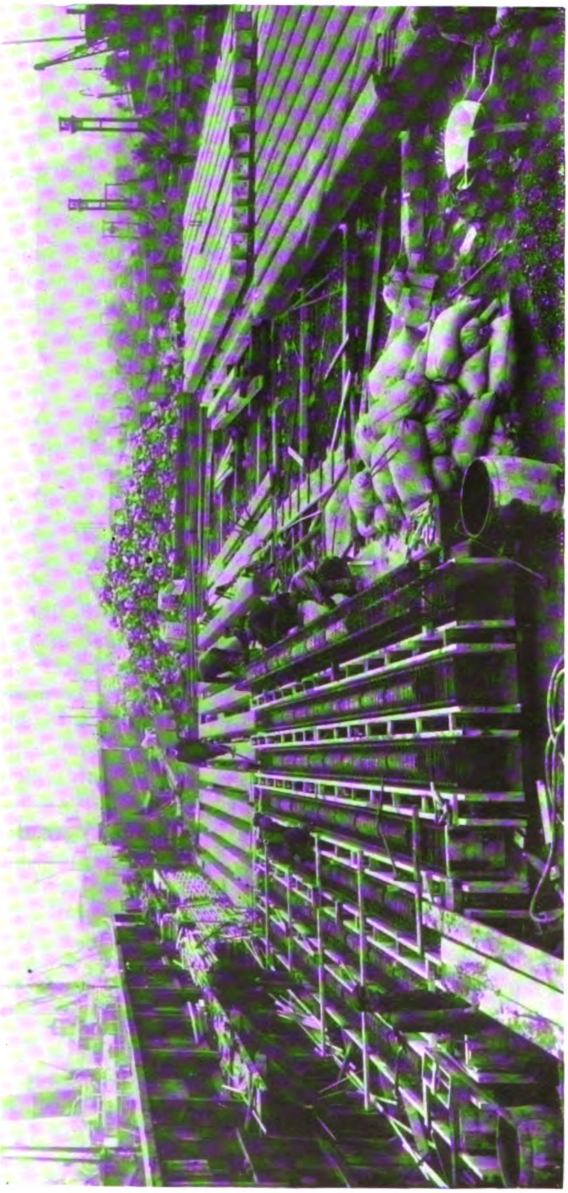
Part of Roadside Front during Construction.

THE BROCKLEBANK WHARF.

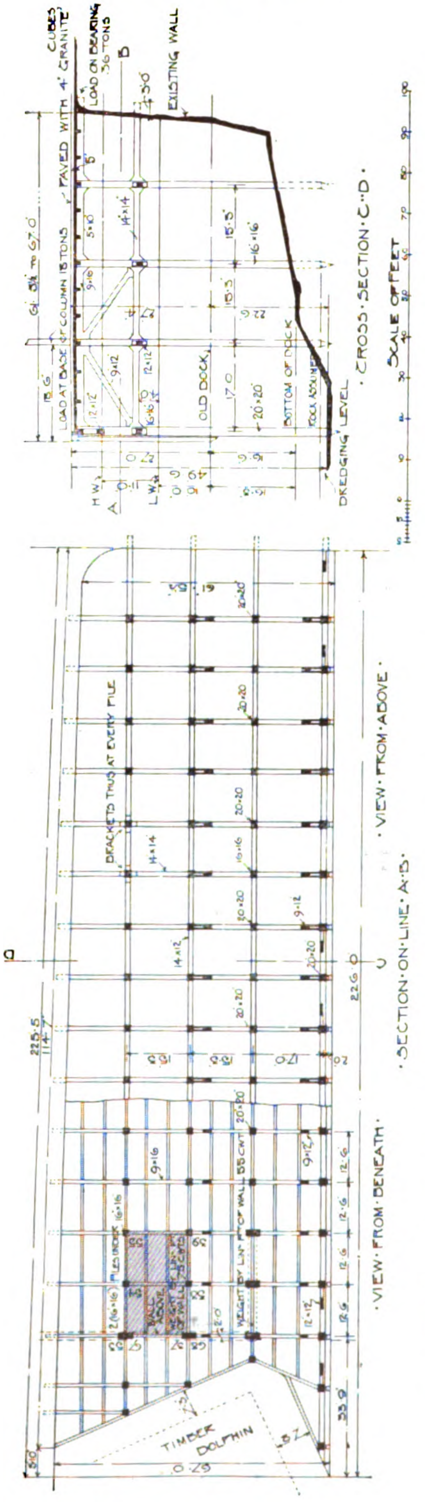
Brocklebank Wharf, as we may conveniently distinguish the new reinforced concrete wharf, extends from the east wall of the dock for the length of 226 ft. along the north wall, its width being 61 ft. 6 in., and its height from the new dredging level 49 ft. 6 in.

The general design of the wharf is shown in a plan and section. Briefly described, the wharf consists of 71 reinforced concrete piles driven into rock below the dock bottom. The piles are connected at the distance of about 4 ft. above L.W.O.S.T. level by longitudinal and transverse walings, also of reinforced concrete, and continued upward in the form of columns, braced above the walings by diagonals, and connected at quay level by longitudinal and transverse main beams between which are secondary beams. Over the entire series of beams is a continuous decking slab paved with granite setts.

Apart from the quay paving and the timber fenders along the front for the protection of vessels, the work is entirely of reinforced concrete moulded in absolutely monolithic connection and further tied together by carrying the ends of the steel reinforcing bars from one member to another. The whole constitutes a rigid framework without joints of any kind, and whose resistance is increased to an enormous extent by the decking which really acts as a huge hori-



Piles for the Brocklebank Wharf (in course of construction).



zontal beam. Finally the wharf itself is anchored to the east and north dock walls by forming the ends of the walings and beams of extended cross section and building them into the solid masonry.

The piles were prepared in advance on the site by assembling the longitudinal and transverse reinforcement for each member in a horizontal mould which was then filled with fine concrete carefully tamped in position. The process of pile manufacture is shown in a photograph. The piles there shown are the Mouchel patent hollow diaphragm type, which in virtue of the interior space can be made of unusually large dimensions without exceeding practicable weights. Moreover, as piles have also to perform the duty of columns in withstanding the combined effects of direct compression and flexure, the disposition of the reinforced concrete about a hollow core is stated to be more advantageous than the employment of the same amount of material in the form of a solid cylinder.

All the piles of the type here described measure 20 in. square, but some of smaller section in other parts of the wharf were moulded solid.

After the piles had been moulded they were stacked in the yard until fully seasoned, and were then slung and pitched in position ready for driving.

One of our illustrations shows one of the piles being slung over the north wall of the dock, several piles driven in place, and the lighter, on which the driving apparatus was installed.

The operation of driving was performed by the aid of a heavy monkey falling upon the usual timber dolly, the force of the blow being uniformly distributed over the head of the pile by a cast steel cap filled with sand.

After each pile was driven to refusal, the concrete was stripped away from the upper end at the level of the horizontal walings, the reinforcing bars of which were passed between the exposed reinforcement of the columns. Then the ends of the walings were moulded into the body of the piles so as to secure absolutely monolithic construction. At the same time bars for reinforcement of the columns were connected to the projecting ends of the pile bars and the columns were built up after completion of the walings.

The piles are driven at distances apart of 12 ft. 6 in. centre to centre in four rows, which are 17 ft. and 15 ft. 3 in. apart, the distance between the innermost row and the north wall of the dock ranging from about 10 ft. at the east to 17 ft. at the west. Consequently for the greater part, the decking is divided up into bays with the dimensions of 17 ft. by 12 ft. 6 in., and 15 ft. 3 in. by 12 ft. 6 in. Each of these bays in turn is divided into three panels by two secondary beams, and over all the beams is the continuous deck slab, 5 in. thick.

In August this year a portion of the Brocklebank Wharf was subjected to severe load tests, under the direction of the dock engineers, the area selected being that indicated on the plan.

The following may be taken as a reliable summary of the tests :—

RESULT OF TESTS.

The wharf was designed for the working superload of 6⅔ cwt. per sq. ft., the test load being specified at 10 cwt. per sq. ft.

For the measurement of deflection seven exact instruments were placed beneath the deck beams and slabs at the points marked in the diagram. The entire area, measuring 22 ft. 6 in. by 15 ft. 3 in., equal to 343 sq. ft., was then loaded up with gravel, weighing 27 cwt. per cub. yd., to the height of 10 ft., making the total superload of 171½ tons, or 10 cwt. per sq. ft.

The resulting deflection in the main transverse beam, instrument No. 1, was ¼ in., and the set immediately after removal of the load ⅛ in. only.

In the four secondary beams, the deflections at instruments Nos. 2, 3, 4 and 5 were ¼ in., 3/16 in., ¼ in., and ⅛ in. respectively, and the corresponding amounts of set on removal of the load were 3/32 in., 1/16 in., *nil*, and 1/16 in. respectively.

At the middle of the two deck panels the deflections according to instruments Nos. 6 and 7 were 3/16 in. and ¼ in., the corresponding set on removal of the load being 1/16 in. and 3/32 in. respectively.

The amount of set cannot correctly be described as permanent, because sufficient time had not elapsed for the beams and slabs to resume their original form, but even admitting for the sake of argument that the deflection had been permanent, the deformation under the heavy test load imposed was exceedingly small and sufficiently demonstrates the perfectly satisfactory character of the construction.

Brocklebank Wharf was also completed from the designs of Mr. Anthony G. Lyster, M.Inst.C.E., who here likewise had the co-operation of Messrs. Mouchel & Partners, Ltd., on the reinforced concrete work, which is constructed on the Hennebique system. The contractors were Messrs. Edmund Nuttall & Co., of Trafford Park, Manchester.

CONCRETE AND FIRE RESISTANCE.

SOME COMPARATIVE TESTS.

WATER BEING APPLIED TO TEST PIECES AFTER FIRE.

In presenting certain illustrations as to the fire tests in the United States, we are indebted to Mr. Humphreys, of the United States Geological Survey, for data, and also to our contemporary, the "Cement Age," for some of the illustrations and particulars.—ED.

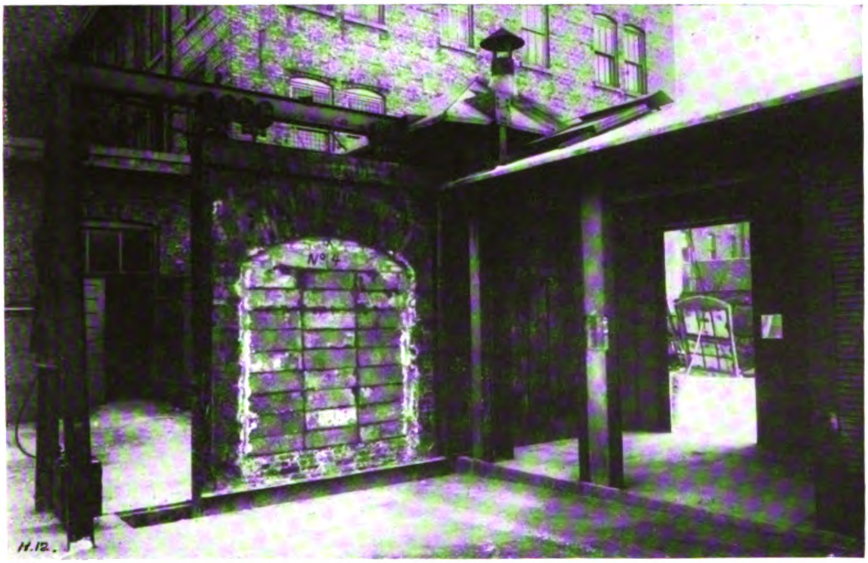
WE have from time to time dealt with the great advantages of using concrete for building purposes where a high fire resistance is a matter of importance, and here we would remind the reader that to meet the conditions of a warehouse or factory fire the structure should have the power to resist the effect of a fierce fire at high temperature for a long period, as also the effect of water applied under pressure.

We fully realise that there are numerous materials that will withstand fire for short periods and at moderate temperatures, notable amongst them being the " Dense Terra-cotta " which was a favourite material in this country for fire-resisting floors in bygone days, and which is certainly quite useful under the mild conditions met with at fires in domestic buildings. Materials such as fire-resisting glass will withstand temperatures up to 1,500° Fahr. for one and a half hours, and will not then show much effect from the immediate subsequent application of water from the fire-engine. Ordinary oak doors will likewise give a good showing if of a thickness of two inches and properly put together. But for fires that burn furiously and long and where the sudden application of streams of water from fire-engines has to be contended with, good concrete has as yet been unsurpassed as a fire resistant.

The fire resistance of concrete, which by those who have any real knowledge of fire prevention has now long been recognised, has, however, been recently again questioned on the occasion of a fire at the Parker Buildings, New York, when certain parts of the terra-cotta construction made very bad showing. The building having unfortunately been described as "fireproof," and the man in the street not being able to discriminate between the materials used in construction, wrongly assumed that this structure was a concrete one, and thus he expressed much wonderment at the failure.

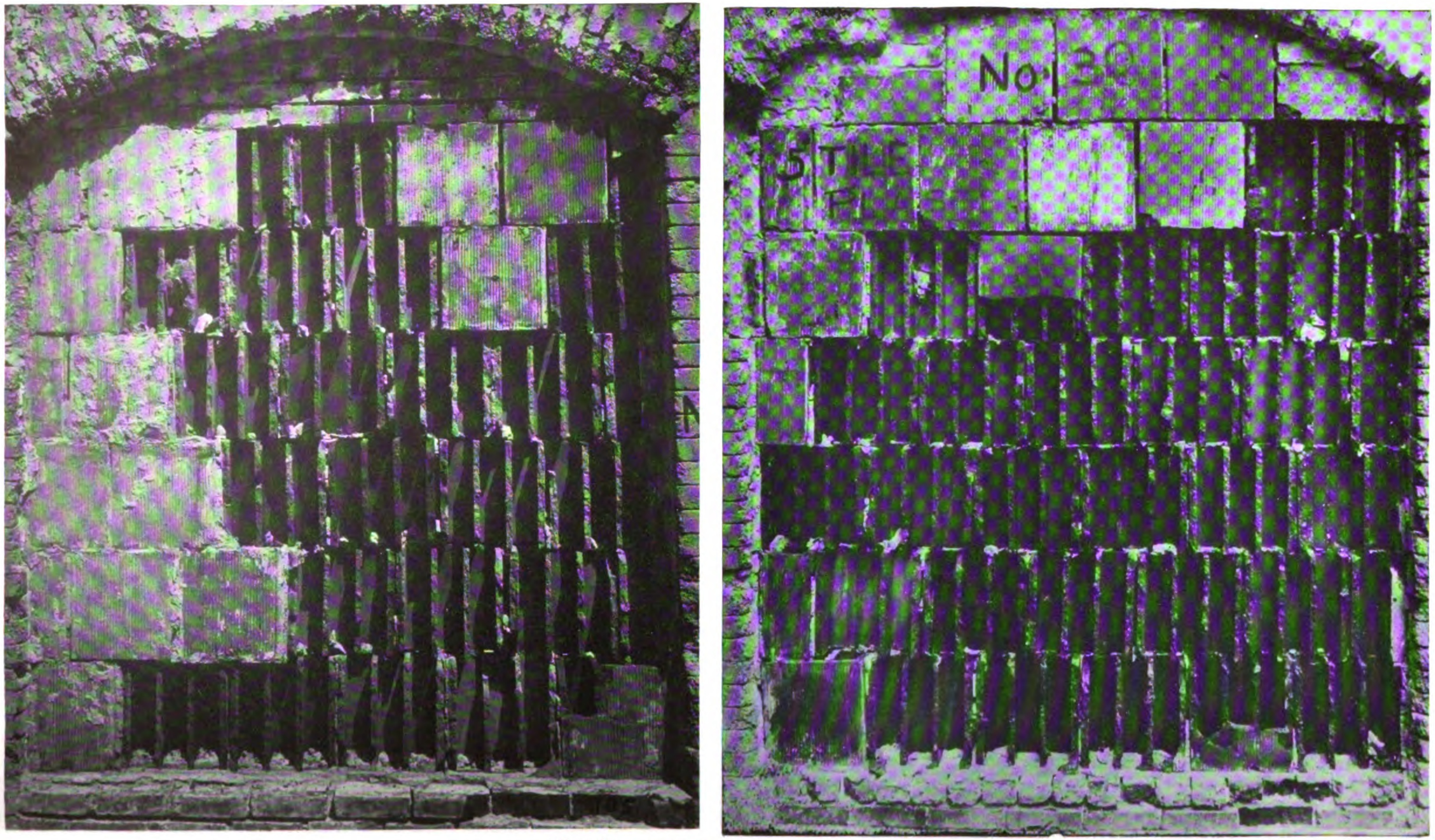
As to the fire resistance of concrete and the relative resistance of different forms of concrete, we have in an earlier issue presented some data of an official fire test of the British Fire Prevention Committee with floors of different concrete aggregates, a test which had been made at the request of the Associated Portland Cement Manufacturers, Ltd., and was undertaken with a view of obtaining data in respect of the high fire resistance of concrete when used with a fine ground Portland cement, such as " Ferrocrete " Brand, which was used in these particular tests. Results of these three-hour tests will be found in our Volume I., page 60, and all showed the excellence of the concrete, with the one exception of the concrete where Thames ballast was used as an aggregate.

These London tests have recently been further extended by some experiments conducted at the Fire Underwriters' Laboratories at Chicago with different forms of building materials vertically placed, and whilst the British tests referred to dealt solely with concrete of varying aggregates, these American tests give some additional particulars as to the relative fire resistance of different forms of concrete versus dense terra-cotta and versus certain natural materials. We should add that the tests that have been undertaken had the assistance of the American Government, and that the first series, of which we present some illustrations, were tests with panels arranged as illustrated on these pages, the materials being subjected to the direct application of fire for two hours, immediately followed by the application of water from a steam fire-engine. As far as the character of the fire is concerned, an effort is always made to raise the temperature to 1,700 deg. Fahr. during the first half-hour and to continue at that temperature for the remaining one and a half hours. As to the results, as in the case of the British tests, the photographs presented speak for themselves to an extent which makes description almost entirely unnecessary. One only has to look at the views of the panels of dense terra-cotta and compare them with the others to again realise that the leading authorities on fire protection have not overstated the case against terra-cotta as a fire resistant.

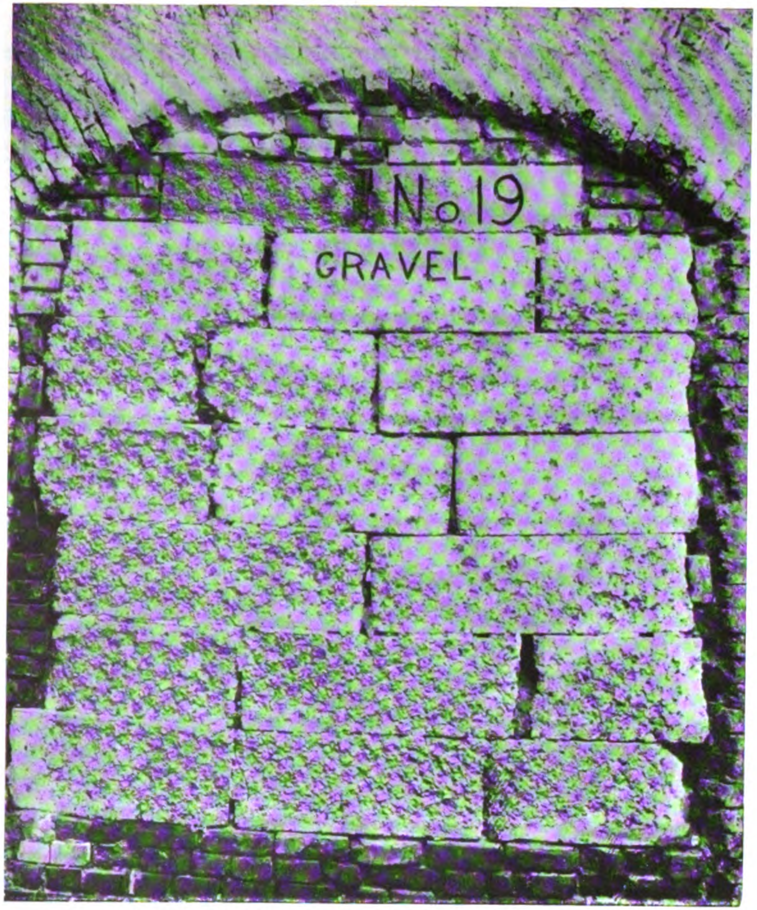


Vertical Testing Apparatus for Fire Tests at Chicago.

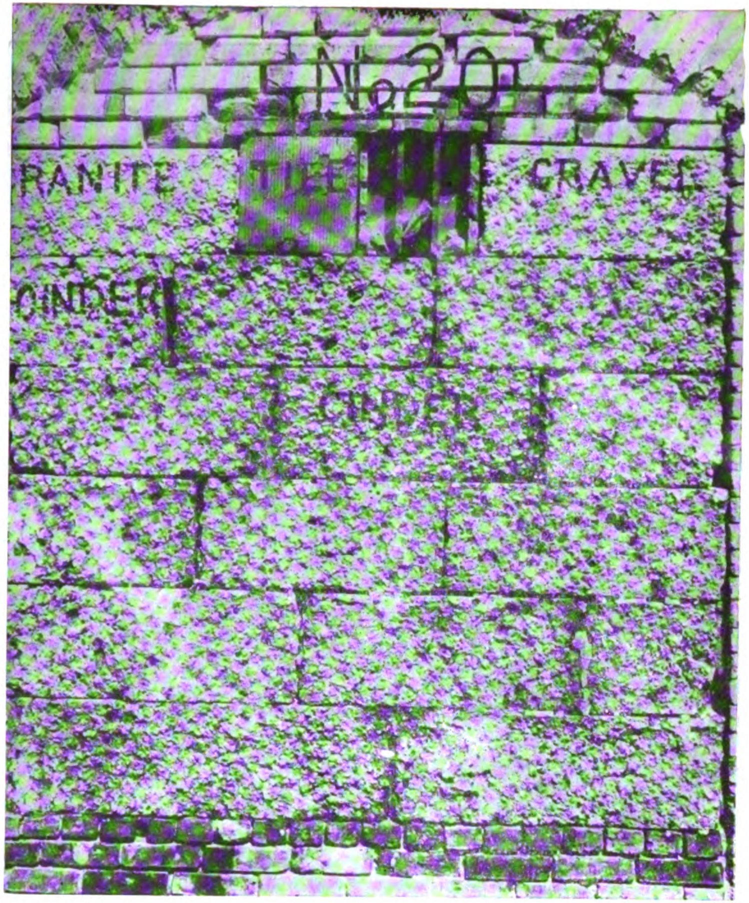
Only in one direction would we supplement the illustrations, and that is to point out that these American tests brought out very clearly the low rate at which heat travels through concrete. Linen tags which had been placed inside some of the hollow concrete blocks were actually found undamaged, *i.e.*, not even scorched, after the fire test. It was also very noticeable that the richer the concrete was the less it was affected by the fire test; that the concrete mixed with the greatest percentage of water gave the best results; in other words, the wetter, richer mixtures stood better than the leaner and drier test pieces. If this lesson be learnt as to the mixing of concrete and the reminder as to the poor showing of dense terra-cotta again be put before the public, the utility of this new series of tests will be obvious.



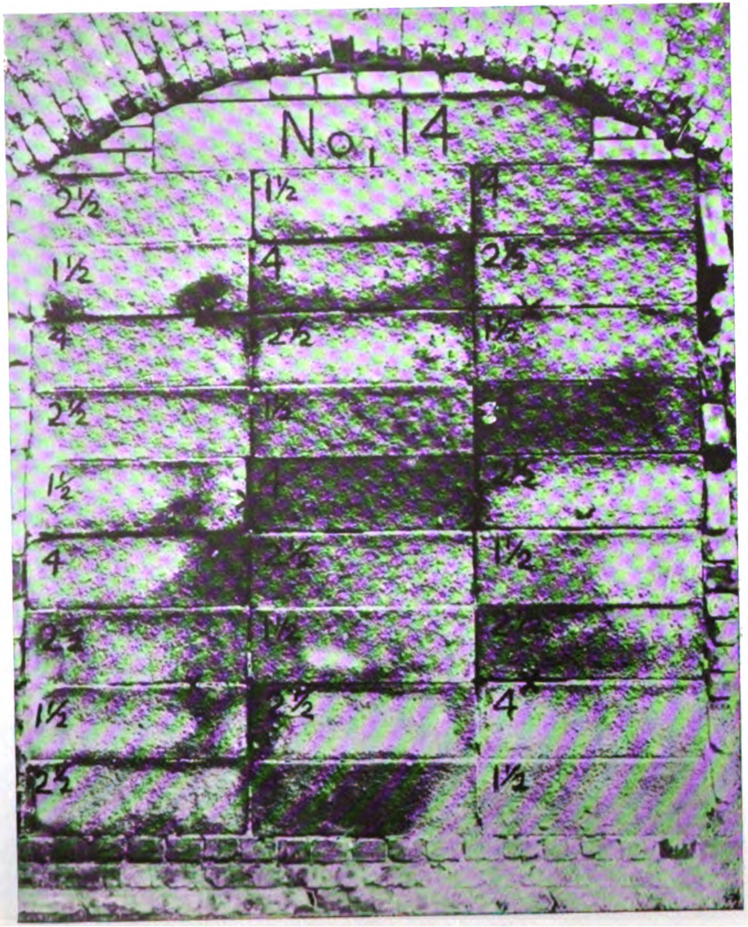
Fire Test with Dense Terra-cotta.
(Subjected to 1,700° F. for 2 hours, followed by application of water.)



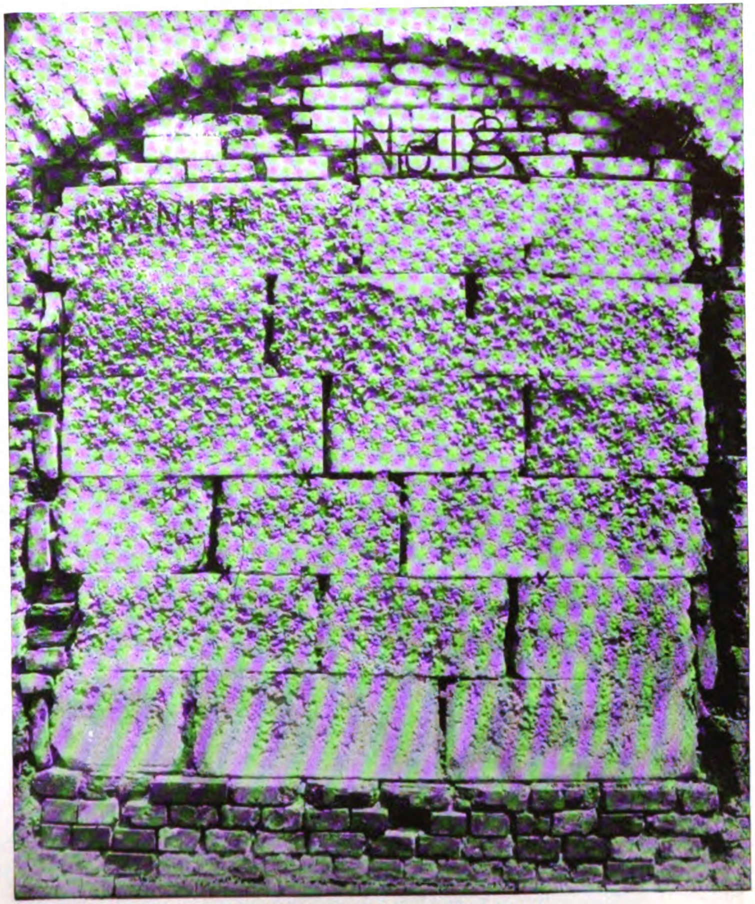
Fire Test with Gravel Concrete.
(Subjected to 1,700° F. for 2 hours, followed by application of water.)



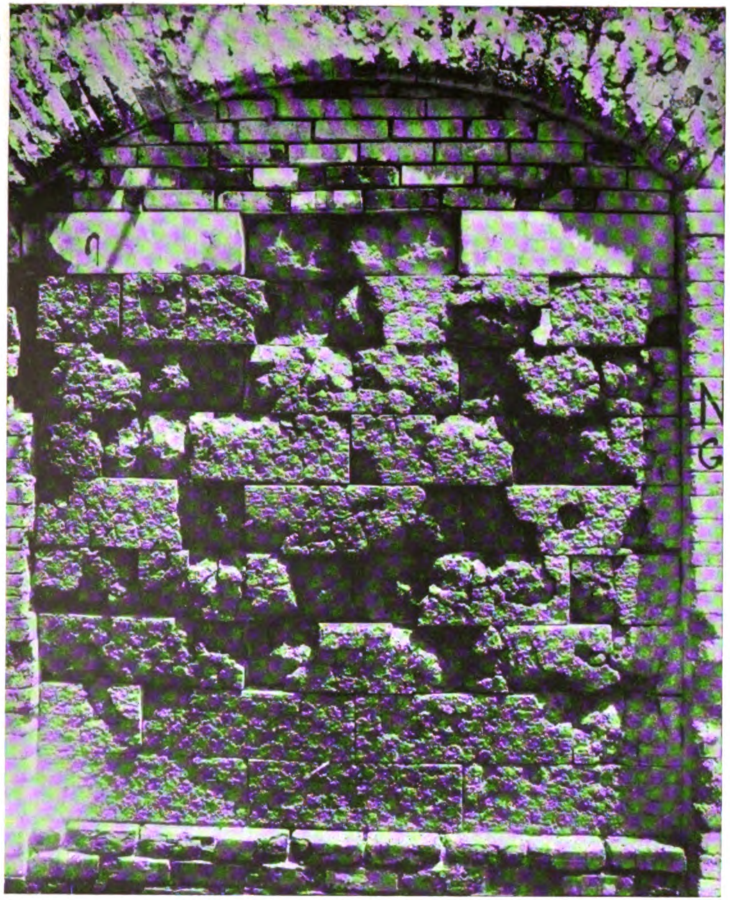
Simultaneous Fire Test with pieces of Dense Terra-cotta and Concrete, having respectively Gravel, Granite and Cinder as Aggregate.
(Subjected to 1,700° F. for 2 hours, followed by application of water.)



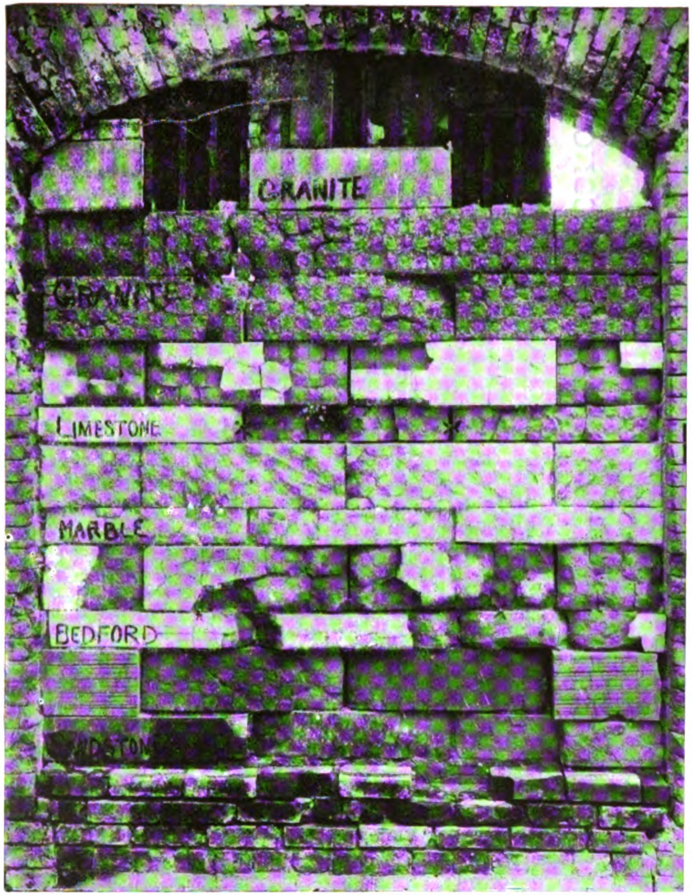
Fire Test with Dry-Tamped Cement Blocks.
(Subjected to 1,700° F. for 2 hours, followed by application of water.)



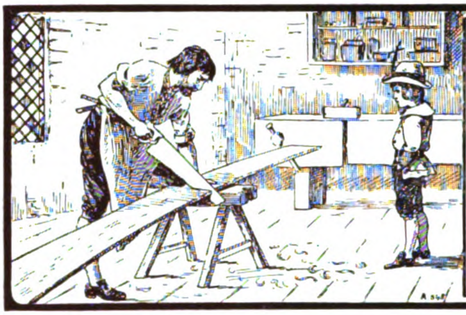
Fire Test with Granite Concrete.
(Subjected to 1,700° F. for 2 hours, followed by application of water.)



Fire Test with Natural Granite.
(Subjected to 1,700° F. for 2 hours, followed by application of water.)



Fire Test with Various Building Stones (Granite, Limestone, Marble, etc.), and some pieces of Dense Terra-cotta.
(Subjected to 1,700° F. for 2 hours, followed by application of water.)



ROUGH AND READY REINFORCED CONCRETE CONSTRUCTION AT FACTORIES OR WORKS.

The following article is being published, because we receive so many enquiries from Works Managers or Heads of Building Departments connected with works asking for particulars as to rough and ready means of executing work in reinforced concrete.—Ed.

A VERY large number of works and factories in Great Britain have trained Building Departments or Clerk-of-Works Departments, which carry out all ordinary alterations. and frequently also the simple new structures. The Clerk-of-Works Department employs its own labour, buys its own material, and in fact acts in every way as builder.

It is contrary to the rule of most of these works to have any outside labour on their premises at all during such operations, *i.e.*, they refuse point blank to have any outside contractor or specialist contractor within their boundary walls.

As it is our desire to increase the uses of concrete and reinforced concrete in every direction, and as we have been constantly receiving enquiries for particulars, we are presenting below some useful hints extracted from an article by Mr. Warren H. Miller, of the United States, which has been published in the *Engineering Record* of that country, and which certainly claims attention on this side of the Atlantic.

Mr. Miller's article does not enter into the specific design or system of design to be adopted, assuming that the rough and ready work required can be designed by the works engineer or works surveyor, and that such reinforcements as are desired can be purchased from ordinary mills or from specialist makers, as the case may be, and brought into the place. Of course there is one grave danger in what we will term amateurs attempting reinforced concrete construction if ignorant of the primary elements of this form of work. They may have accidents or "collapses" from sheer lack of experience. It would thus be well that they limit their work to the simplest kind, or that for the present when attempting anything of an extensive character they obtain the necessary information from a consulting engineer or from the outside specialist from whom they purchase their reinforcements before commencing work.

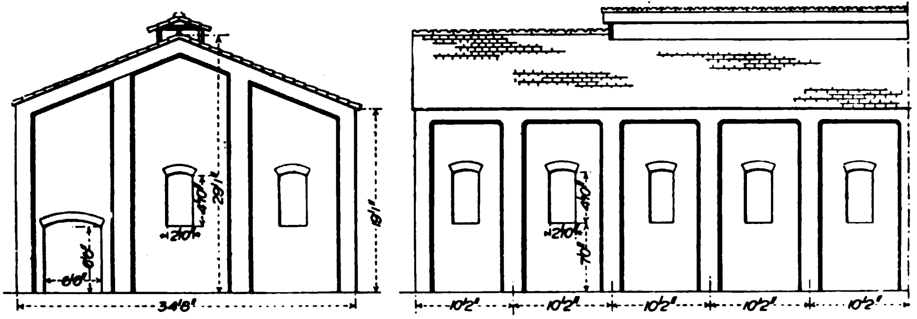
There is one point, of course, in favour of work being carried out by the works management; there is generally not the slightest fear of there being any scamping or any purchase of poor material.

MR. WARREN MILLER'S EXPERIENCE.

For most shop buildings a 10-yard mixer will keep a gang of fifteen men hard at work and will run the concrete end of the work plenty fast enough. Concrete wagons, holding about 6 cu. ft., are a necessity for economical work, though many prefer wheelbarrows, because of the one-plank runway and greater facility in pouring. The writer, however, having used both, can see no question but that the concrete wagon is far quicker. Do not attempt to figure these in 6-cu. ft. capacity; it is seldom that a runway is smooth enough to handle over 5 ft. without spills. Another exceedingly handy implement is the small mixer barrow. These are made to hold exact multiples of a bag of cement, so that it is easy to get accurately any mixture desired without losing any time on further weights or measures.

For runways it is well to invest in a few 4 x 12-in. yellow pine planks, 30 to 40 ft. long, and keep them on hand for all concrete work about the plant. They seem to last indefinitely and cannot be run off with for scaffolding or otherwise mislaid. The marvellous way in which piles of 1½-in. rough construction planking in 14-ft. lengths disappear is a matter that every construction man will recall with suppressed rancour. Eight of the 40-ft. planks will carry 160 ft. from the mixer, and a pair of them will carry a concrete wagon over 14-ft. spans with ease. It takes the whole mixer gang to move and place one of them, so there is no danger of the plank being " borrowed " by the pipe-fitters, or the electricians, or others in need of temporary staging.

Another method of solving the runway problem is to have none at all. One of the best runways ever invented is a pole derrick with electric hoist located beside the mixer in the centre of the building site. It serves both walls and the end of the building, using a bottom trip bucket. The rammers and placers on each wall work on light scaffolding used by the carpenters in setting up forms and follow the bucket with a broad iron chute of 18-gauge sheet.



General Outlines of Reinforced Concrete Shop.

Where electricity is available it makes by far the most flexible derrick and mixer drive. Next comes the kerosene or gasoline engine, and finally steam. The electric motor should be heavily fused, as the mixer often puts on it extreme momentary overloads. About three times the normal current of the motor gives a fuse that will " stay put."

The success of concreting depends upon two factors, each equally important, the carpenter work and the selection of the mixtures. The former requires strong, accurate work by the men on the forms and careful inspection at every point by the engineer in charge. Pilaster forms should be vertical 1½-in. plank, Southern pine, dressed one side and ship-lapped. The corners are filled with 1 in. 45 deg. bevel strips, and an inch bolt is provided about 9 in. from the top and bottom of each pilaster form, so as to permit raising it as the work progresses. Twelve or 14-ft. yard run of planks will do for height. The pilaster forms are accurately located on the foundation walls, plumbed to a line stretched across their tops and braced securely in place. Each one should be bevelled at its inner edge to provide a corresponding fillet in the concrete pilaster corner, and a strip should be nailed along each edge to provide a stop for the panel planks. Finally, they are all given a coat of crude paraffin or soft soap to prevent concrete sticking to them, and the work is ready for the panels.

These are made in two halves for each panel, which meet in a bevel joint in the centre of bay. The planks should be 1½-in. spruce or Southern pine, ship-lapped, dressed one side, and should invariably run horizontally. It is impossible to prevent a trace of cracks showing on the concrete, and these should run horizontally for the sake of looks. After setting up and truing, the panels are painted inside with the same compound as the pilasters. The interior wall can now be run. It is best made perfectly flat. The panels need not be a scrap over 6 in. thick in bays of 12 ft. on centre lines of pilasters, the latter being 28 in. face.

The height of forms that may be set up for a single pour depends upon the arrangement of the runway and the amount of money it is proposed to put into false-work. Five to 6 ft. is the usual height to a pour, though the construction companies usually pour a whole story at a time, as they carry a greater proportion of forms to finished work than it pays to do in factory engineering. They use the same forms on other buildings, and the works office usually intends to do likewise, but the writer has never yet seen forms that were " used again " about an industrial plant, unless it might be for some such matter as a tank or bin or foundation piers for another building.

No matter what height is selected for the pour, the top plank must be separable from the rest of it, being only toe-nailed to the cleats with light nails. The reason of this is that it is not possible to take a form from concrete and move it up the wall without getting some irregularity in the surface, always unsightly and often forming a ledge ⅜ in. deep in spots. If, however, the concrete is poured to the middle only of the top plank and the latter is left in place, it is easy to raise the rest of the form and set it accurately into the tongue of the ship-lap of the top plank. In this way a perfectly smooth flat wall is obtained. There will always be a discernible difference in colour between each successive pour, necessitating a final coat of 1 : 2 cement paint to secure finished, uniform and weatherproof work. While on the subject of panels it may be well to explain that the reason for parting the panel in the centre is to enable the form to be struck without injuring either it or the green concrete. If made in one piece the panel will surely swell and jam tight into the pilasters at each end. By the time it is finally pried off it is mostly splinters and the wall a picturesque ruin.

Another matter that must be attended to is the lateral pressure of wet concrete. No plank will stand over 3 ft. head of wet concrete without bowing out. All wall and pier forms must be tied together by rows of bolts or wire ties some 30 in. apart vertically, and 3 ft., more or less, in the row. The construction companies use bolts very extensively. It is a good thing if each bolt is perfectly straight and every one of them is given a round turn just after the concrete sets. But the writer prefers two or three turns of No. 14 iron binder wire, twisted tight against a wooden spreader. As the concrete reaches the spreaders they are knocked out and saved for future use. The wires may be twisted tight with a 20-d nail inside the form or tightened with wooden wedges driven outside. After the concrete sets, the wires are cut across on the outside of the forms before striking the latter and are left in the wall. Before painting, the ends are nipped off close to the surface and all trace of them disappears. With bolts the holes must be plastered, and no amount of careful work will obliterate the regular rows of patches.

After the carpenters are through and the wires secured, the wall is ready to pour, except for quantities of débris, sawdust, chips and small blocks of wood, which have collected on the bottom. Unless the engineer on the job expects to go fishing for these with a jab-hook, slots must be cut in the panels of the interior wall forms at regular intervals to sluice out the dirt. These may be 2 x 12 in., cut horizontally in the bottom plank. A fire hose will run out all débris through these slots.

Before pouring the section, see that all reinforcing rods, window forms, beam-end moulds, and the like are in their proper place. The rods must be securely fastened with blocks and wire or the rammers and wagon men will drive them everywhere but where they should be. The men seem possessed with the idea that the reinforcing rod must somehow be worked out to the centre of the wall, and it is hopeless to argue with them on the error of this proceeding.

Wall forms may be struck in two days in summer, four to six in winter. If a nail will hardly scratch the green concrete it is safe to strike the form. For floorbeams and ceilings at least a week or ten days is necessary to give the concrete the requisite strength in summer and much longer, say, two or three weeks, in winter.

The subject of mixtures is worthy of considerable study to get the best results. In the ideal concrete the sand exactly fills the voids in the stone and the cement fills the voids in the sand. Thus the heavier per cubic foot the better is the concrete, and the greater the proportion of cement to sand the stronger it is. It will not do to use the flat proportions, 1 : 2 : 5, 1 : 3 : 6 and others given in the text-books. The 1 : 2 : 5 mixture may be strong, because of its mortar, but it seldom gives good results in walls or anywhere else. There is not enough mortar to more than fill the voids, and a surplus must be allowed for unless the wall is to have bad spots all over it. This is because it is impossible to pour 1 : 2 : 5 concrete from a wheelbarrow or buggy, though it can be done with a drop-bucket. The first thing that comes off the wagon is pure, sloppy mortar; next a quantity of stone, with hardly enough mortar to properly fill its voids, and finally the bulk of the wagon-load nearly as mixed. The result is that the first mortar poured runs along the wall and accomplishes little; the layer of stone depends mostly upon the excess mortar of the main charge, which has hardly enough as it is. It is impossible to reach the bottom of this with rammers, and so a bad spot is formed, which must be plastered up later by hand.

A 1 : 3 : 5 mixture, with the sand a trifle scant, gives very good results, making a strong wall that will be smooth and finished when the forms are taken off. In any case, by the time the pour is up to the top of the forms there will be about 4 in. of nearly pure squish or excess mortar, more or less. If the works manager gets his eye on this he will be for an immediate dumping of wet stone into this mortar, to make good the apparent wastefulness. If he insists on having that stone put in, well and good, but you can safely predict a parting line of nearly raw stone that will render the wall peculiarly pervious and unsafe. This is true, even in walls 18 in. thick. To gain a few cubic feet of concrete at the expense of the safety of the whole fabric is not economy and is only a little worse than skimping the mortar to spend twice its cost in hand patching.

As to the amount of water in the mixture, the sloppier, within reasonable limits, the mixture the smoother and finer the wall. The concrete will reject all the water it does not need. You will find it an inch deep on top of the pour when it is done. To make the concrete thick as ordinary plaster mortar is simply to invite spots and introduce a quantity of unnecessary ramming.

Whenever expanded metal is used vertically, as in walls, the writer has found it desirable to use cinder concrete. Unless the stone is about the size of gravel it is likely to bunch and jam in front of the expanded metal. If rammed it immediately presses the latter out against the form. No such trouble exists in horizontal expanded metal work, such as floor slabs.

The writer, however, uses cinder concrete on nearly all works construction. It is amply strong enough; is easily cut and bored; and the cinder is always to be had for the screening at the power plant. For rod-reinforced panels and columns rock concrete is preferable, giving smoother and stronger work. In footing work remember that you are dealing with soil having usually a bearing capacity of 2 tons per square foot, so that there is no need for rich mixtures in the concrete. The 1 : 4 : 9 cinder concrete will do for most footings, the proportion of ledge to depth being the same as brickwork; it is much preferable on the score of homogeneity to trenches filled with rubble or hardheads and then grouted. This latter appears cheap, but when one considers that it calls for two fillings, stone and grout, and that many mixers cannot make mortar, the cost sheet lies all the other way.

In large, heavy masses, such as trestle piers, engine and steam hammer foundations, and the like, the best results are obtained by going to a 1 : 4 mortar. Cinder concrete mixed 1 : 4 : 5 will pour a beautiful trestle pier, smooth and clean and never requiring patching. It is amply strong for the work, as has been well proved in practice. Cinder concrete of 1 : 3 : 5 proportions gave very unsatisfactory results in the same pier forms, having rough spots and poor corners in nearly every pier. For steam hammers and other tools subject to severe shock, there is nothing to excel the 1 : 4 : 4 rock concrete mixture. Some still finer foundations have been turned out in 1 : 4 : 3. The essential point is to get a dense homogeneous mass that will not be pervious to every oil drip and water leak underground.

In all such foundations economy lies in training some handy man to the work and using 1-in. rough hemlock for the forms. Foundations run mostly too small to warrant cutting up plank for them. The difference in cost of these hemlock forms over plank ones set up by an expensive carpenter is surprising. The millwright is the man to hold responsible for the setting of the bolt template, and this is really the only point in a tool foundation calling for accuracy. This same handy man will do a very creditable job in all such forms as concrete post underpinnings for wooden buildings, foundation walls, sumps, valve-pits, concrete trenches and such work.

Much construction work is now undertaken late in the fall and carried on all through the winter. There is no particular difficulty in working concrete during the winter months. When working with the yard force it is well to make a rule never to pour below 30° and stick to it. An experience extending over a number of years in winter concrete work shows a surprising number of days in December, January and February when the thermometer was anywhere from 40° to 70°. Most of the time of concrete construction work is consumed in taking down and setting up forms, adjusting runways, setting reinforcement and checking up carpenter work. The actual pouring of a section rarely takes more than an afternoon's work by the yard gang. The days when the mercury is above 32° Fahr. occur frequently enough to get the pouring done without any risks.

If, however, the work *must* be pushed straight ahead there is no great difficulty in working anywhere from 20° to 28°, particularly if the mixer is steam driven. Simply turn the exhaust of the steam engine into the stone pile, burying it good and deep. Get an old stack, build a fire in it and pile the sand all over it. Crack live steam into the concrete water and feed it into the mixer at the boiling point. Just before pouring sluice down the forms with a fire hose into which live steam has been turned, heating the water to 140° or thereabouts. After pouring, cover the top of the forms with bagging or straw. The hot concrete will soft set in about two hours, after which no amount of frost can touch it. Do not use salt in the mixer, unless you prefer fancy patterns in salt crystals all over your wall. For plaster work in freezing weather there is nothing for it but to build a string of fires along the wall. Frost-bitten concrete can be instantly recognised by its dark, greenish colour. Knock it out and re-plaster, as it will never set right after turning. With the above precautions it is feasible to do concrete work in freezing weather, though the writer has seldom seen the time during winter months when it was absolutely necessary to pour on such days.

Concrete Block-Making in Great Britain.

PART III.

By H. KEMPTON DYSON, C.E.

Although the United States, in particular, has been making great headway of late in the production and use of concrete blocks, both solid and hollow, progress in Great Britain has been somewhat slow in this direction, and we have thus pleasure in presenting some particulars as to the industry in this country in the form of a series of articles dealing with the subject both historically, as far as patents call for notice, and practically, as far as modern practice and experience are concerned.—ED.

Messrs. The Patent Victoria Stone Co., Ltd., have also erected concrete slab buildings, the largest being the new smoking lounge at the Lake Hotel at Llangammarch Wells, Brecon.

Mr. W. Calway, of Bristol, late of Gloucester, has, for some years past, erected buildings with concrete slabs. *Fig.* 25 shows the method of constructing buildings which he formerly used, but we understand he has recently made alterations in his system. The materials he uses for the slabs are broken granite with Portland cement in the proportion of 3 to 1. These slabs are afterwards silicated.

The slab method of erecting buildings was recently advertised by Messrs. G. E. Clare, M.S.A., and Walter G. Ross, A.R.I.B.A., who published a book entitled "Ideal Homes for the People," in 1900, and erected a small cottage at Letchworth in 1905. They affixed concrete slabs to a timber frame, sometimes using concrete slabs inside as well, and filling the spaces with coke-breeze or other concrete.

Some workmen's dwellings have recently been erected in Liverpool with large slabs, some 14 in. thick and weighing as much as 11 tons in weight, forming walls, partitions and floors. These slabs were held together with dovetailed joints formed in cement. A special scaffolding is required for such large slabs, and the transport and manufacture are expensive.

From this question of slab building we are led to Mr. Thomas Potter's invention of slabs with a dovetailed lug or projection at each end, which he patented in 1877, illustrated in *Fig.* 26. This system was worked by Mr. Lascelles, referred to in the second part of this article, and a considerable amount of work was done on this system, among which may be mentioned the New College at St. John's Wood, London, N.W.; also the walls of the Town Hall at Epsom were thus constructed.

Mr. Potter states in his book on "Concrete" that a Mr. Charles Drake had introduced plain slabs of concrete with dovetailed grooves cut out of the thickness to form a key for the concrete to attach the facing to the core. Previous to Mr. Potter's invention of the dovetailed

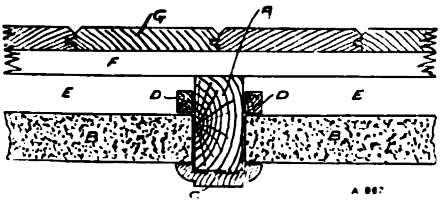


FIG. 25. CALWAY'S CONCRETE SLAB CONSTRUCTION.

A shows framing. *B* concrete slab 2 in. thick.
C capping covering exposed part of framing.
D stops to keep slabs in position. *E* air space.
F batten to which inner lining is nailed.
G inner lining.

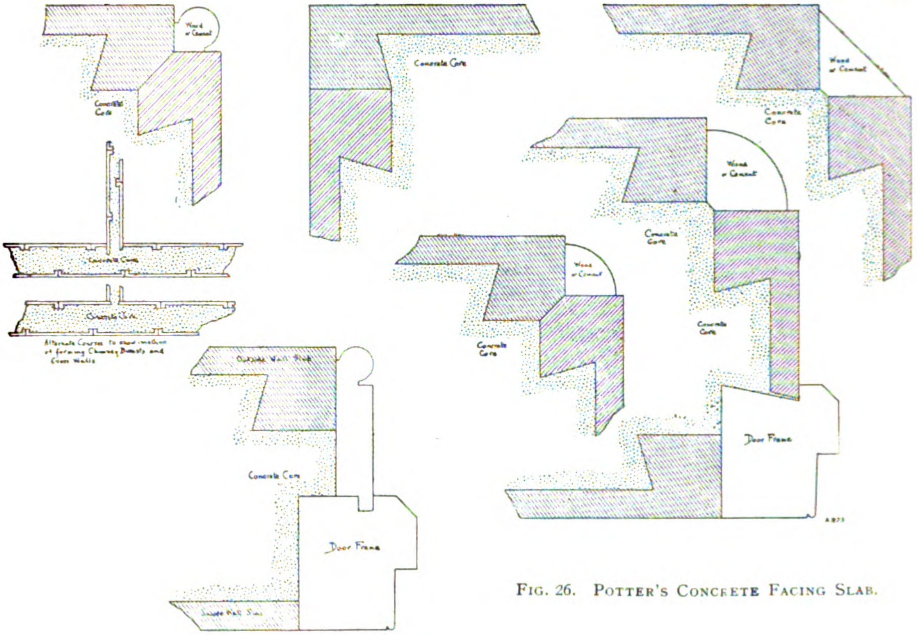


FIG. 26. POTTER'S CONCRETE FACING SLAB.

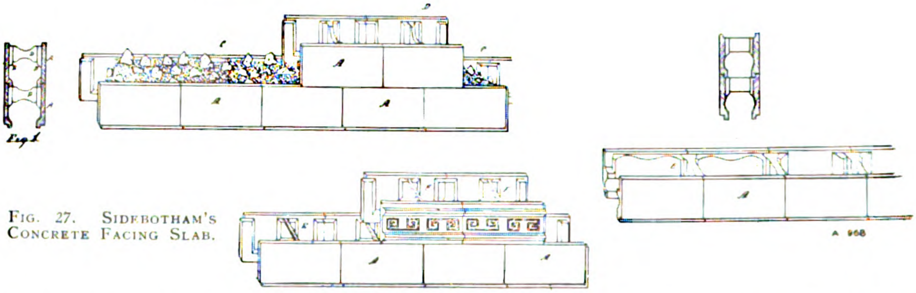


FIG. 27. SIDEBOTHAM'S CONCRETE FACING SLAB.

slab, a Mr. J. Sidebotham, an architect, of Blackpool, took out a patent in 1876 for concrete slabs for walls similar to Drake's. These had two projecting ledges or lugs on the back of each slab, between which a dovetailed groove was formed. Into this groove a transverse slab was dropped. Cement grout was run in the dovetailed crevices and the core was formed of concrete in the usual way. This is shown in *Fig.* 27. Iron or other metal ties of a small size were sometimes adopted in preference to concrete, the ends of which hooked into metal eyes cast in the slabs when in process of manufacture.

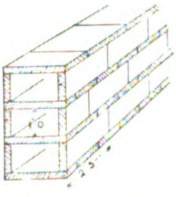


FIG. 28. CORNISH'S HOLLOW SLAB WALL CONSTRUCTION.

Mr. P. Cornish, a builder in Middlesex, in 1877 patented a system of slab construction whereby he used slabs of a plain flat description, set up edgeways, and bonded together by laying similar slabs through the thickness of the wall as shown in *Fig.* 28. He refers to the dryness thus given, and suggests the use of the space for ventilation and warming by hot air.

From this system of slab construction we see an extension by Mr. J. J. Lish, of Newcastle, his patent dating from 1877, who used Z, L or T blocks or slabs, used if desired with straight slabs

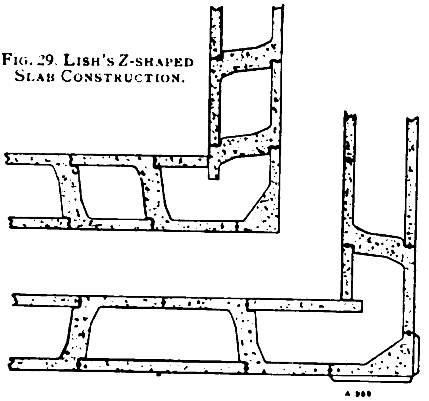


FIG. 29. LISH'S Z-SHAPED SLAB CONSTRUCTION.

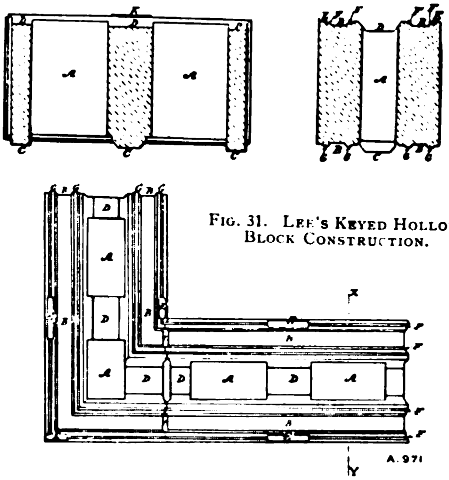


FIG. 31. LEE'S KEYED HOLLOW BLOCK CONSTRUCTION.

Fig. 29 shows this construction. Mr. Lish proposed to fill in between these blocks with concrete or leave the wall hollow.

A Mr. W. Lockwood took out a patent in this same year for an L-shaped block, the form of which is shown in *Fig.* 30, together with details of mould construction.

Mr. W. Lee, in 1878, patented a keyed hollow block shown in *Fig.* 31; Mr. W. R. Cornell, and also Messrs. F. & J. P. West, in 1884, took out patents for slabs panelled (*i.e.*, with depressions) on their inner faces, and Mr. B. Reynard in the same year took out a patent for slabs with dovetail grooves with keys tying the two faces together.

Mr. G. Jackson patented in 1891 slabs with projecting ribs filled in with concrete. Mr. G. Maxwell, in 1892, patented hollow blocks constructed as sketched in *Fig.* 32. A recently introduced form of block construction somewhat novel in detail is shown

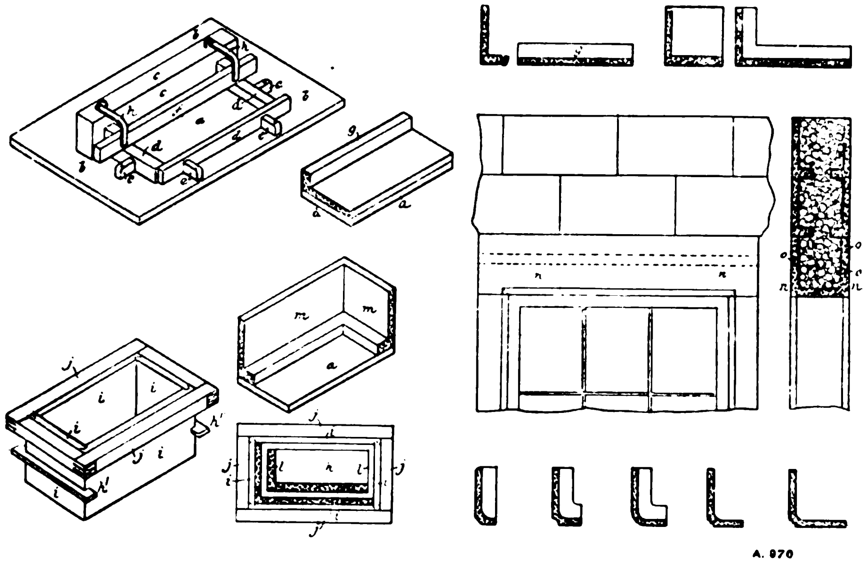


FIG. 30. LOCKWOOD'S L-SHAPED BLOCK, WITH DETAILS OF MOULD.

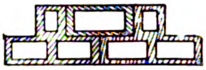


Fig. 32. Maxwell's Hollow Block

in *Fig.* 33. This was patented by Mr. Stidder, and is worked by the Cavity Ventilating Building Block Co., Ltd., of 16 Percy Street, Tottenham Court Road, London, W.

At various dates since similar systems to the foregoing have been introduced. This brings us to quite recent years, and our historical treatment of the subject may be here discontinued.

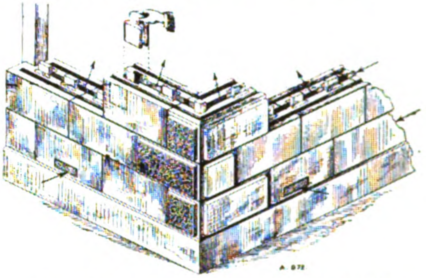


Fig. 33. Stidder's Block Construction.

The chief impetus to concrete block building seems to have been given by the Exhibition of Cheap Cottages erected at Letchworth in 1905, where a building was erected by the Concrete Machinery Co., Ltd., of Liverpool, whose machine is known as the "Pioneer."

The chief progress since in the use of concrete blocks has taken place in the North of England and in Scotland and Ireland. The economic advantages of concrete block building are more apparent in districts where it is difficult to obtain bricks, or country places where building materials cannot be obtained without a long cartage. It is so easy to bring a machine on the site and manufacture blocks with gravel or broken stone, burnt ballast, or any suitable material that is available in the immediate neighbourhood, the only cartage that is necessary being for the cement.

There are several block-making machines on the English market to-day that are being used extensively. These may be generally stated to belong to two types: one in which the blocks are moulded with their external face downwards, and the other in which the face is moulded by a side-plate. Both methods have their advocates, and by either methods satisfactory blocks can be made if the workmanship is good. The "Pioneer" machine, illustrated in *Figs.* 34 and 35, belongs to the second class; it is worked by hand power only, is easily portable, and will make strong blocks 32 in. by 10 in. by 9 in., and three-quarter, half and quarter blocks, as well as corner, joist and bay window angle blocks. For these various shapes and sized blocks a change of mould has to be made, but the change is stated not to take longer than ten minutes.

The cavities in the blocks are, in the case of the "Pioneer" machine, formed by means of plungers which are raised until the concrete has been tamped in the

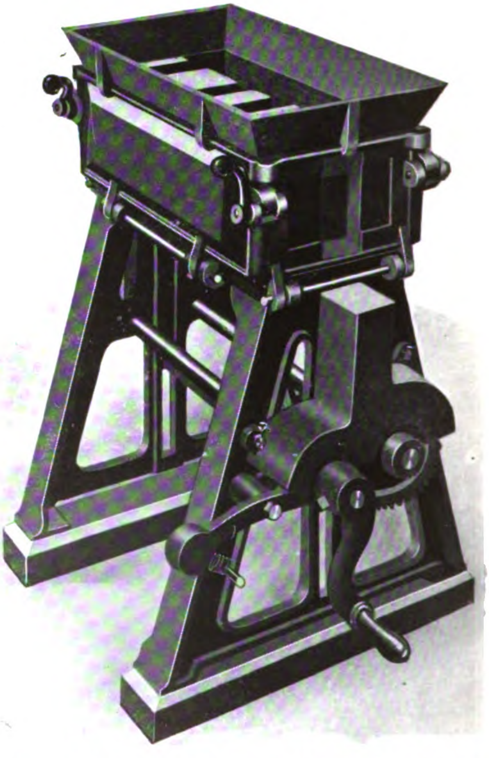


Fig. 34. "Pioneer" Concrete Hollow Block-making Machine in position for putting in Concrete.

mould, and are then, by turning a handle, pulled out and lowered. The face and side plates are then unclamped and turned over on their hinges, and the block removed on a detachable bed-plate which is dropped in the mould before the concrete is placed therein. These sheet-iron base-plates are cheaply made and a large quantity are supplied so that the blocks can be handled easily and stood upon the ground to harden.

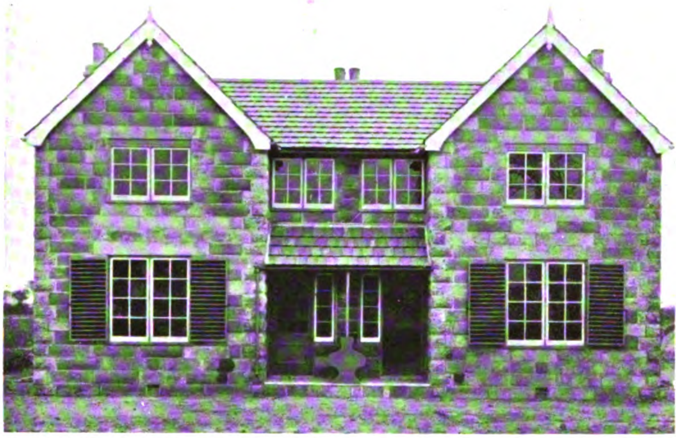


Fig. 36. Pair of Cottages at Boxted, near Colchester, Constructed of Hollow Concrete Blocks.

As regards the lateral stability of walls constructed of blocks made by this machine, we may instance a wall 170 ft. long, partly 10 ft. 6 in. high and partly 9 ft. 6 in. high, which has been built of 10 in. blocks laid in lime mortar, at Hightown, near Liverpool, without any intermediate support between the return walls. This has been built two or three years, and has withstood very heavy gales.

Fig. 36 shows a building which has been erected with concrete blocks made by the "Pioneer" machines. Several contractors have purchased these machines and make a speciality of designing and constructing buildings to their own or architects' designs. The church illustrated on pages 253 and 254 of Concrete and Constructional Engineering for July, 1908, was designed and erected by Mr. Thomas Axtell, M.I.M.E., of Ryhope, near Sunderland, acting as contractor in this way. Mr. Axtell has erected three churches with concrete blocks in the Sunderland district.

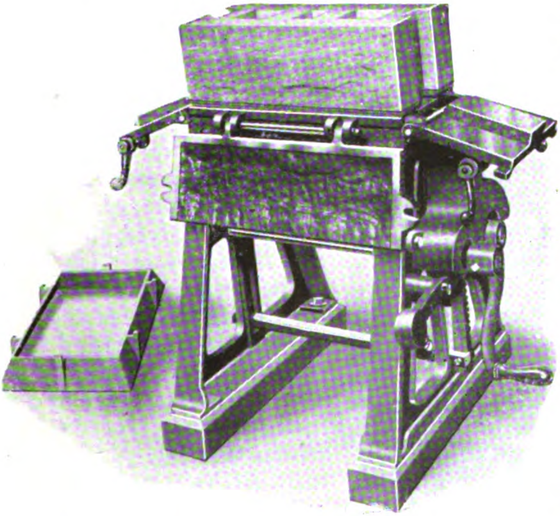


Fig. 35. "Pioneer" Machine in Position for Removing Concrete Block.

Fig. 36 shows one of ten pairs of cottages built for the Salvation Army "Back to the Land Scheme" at Buxted, near Colchester, by Messrs. Walter Jones & Sons, the well-known structural engineers, of 35 Old Queen Street, Westminster, who are also contractors for such work. These cottages have two 12 ft. square living rooms, three bedrooms, a scullery, tool-shed, and earth closet, and were erected for less than £200 a piece.

Other large contracts erected

with the "Pioneer" machines include the new zinc works at Seaton Carew, near West Hartlepool; hotel at Crianlarich, Scotland, and the Parochial Hall, St. Petroc Minor, Cornwall. A large number of dwelling-houses, both large and small, also boundary walls, have been constructed throughout the country, while abroad a new bank at Accra, on the West Coast of Africa, erected by the Bank of British West Africa, was constructed with the "Pioneer" machine, and 18,000 blocks were made on two of these machines for the erection of the European Hospital at Nairobi, Uganda.

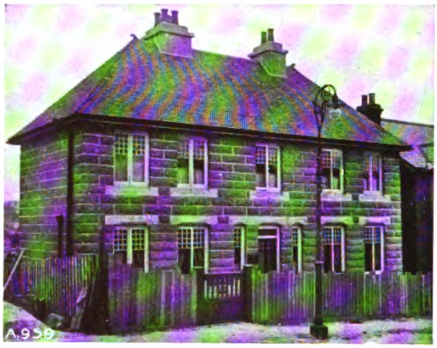


FIG. 37. HOUSE AT HIGH WYCOMBE, CONSTRUCTED OF HOLLOW CONCRETE BLOCKS.

The "Ideal" machine, manufactured in the United States, for which Mr. Matthew Wyllie, of 55 Robertson Street, Glasgow, and Balfour House, Finsbury Pavement, London, E.C., and Messrs. John Pickles & Son, of Hebden Bridge, are agents, is of the face-down type, the cavities being formed by horizontal cores which are withdrawn by means of a lever arm. *Fig.* 37 shows a house at High Wycombe constructed entirely with blocks made by the "Ideal" machine, which has been kindly furnished by Messrs. John Pickles & Son. The block, after the concrete has been tamped into the mould and the cores withdrawn, is removed by turning the front forward; the base-plate at the same time moves up, and this, when inclined nearly vertical, is pushed back so as to allow the block to be removed without spoiling the external face. The machine is shown in *Fig.* 38. The proportions generally used, we are informed by Mr. Wyllie, are 2 sand to 1 of cement for the face, and 4 or 5

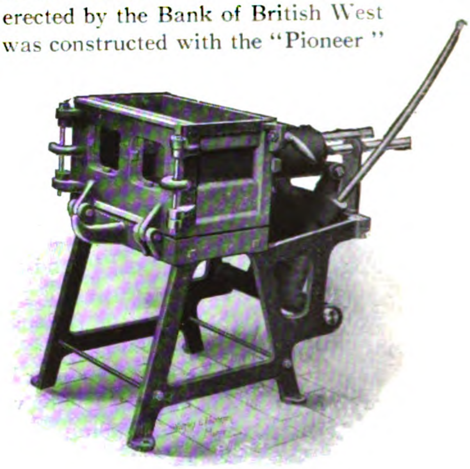


FIG. 38. THE "IDEAL" CONCRETE HOLLOW BLOCK MAKING MACHINE.

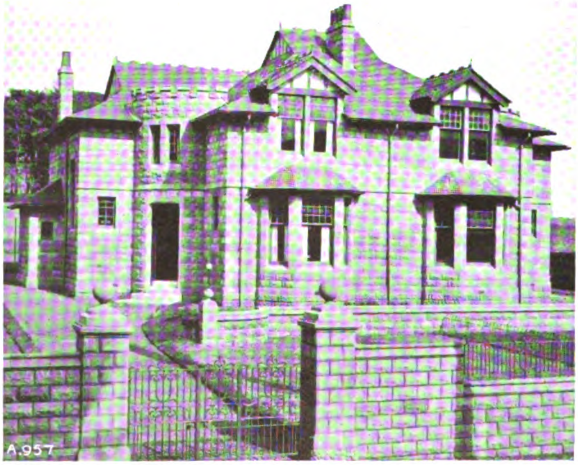


FIG. 39. VILLAS AT PAISLEY, CONSTRUCTED OF HOLLOW CONCRETE BLOCKS.

sand to 1 cement for the body. In some cases good coke breeze is used instead of sand; crushed ballast may also be adopted, or finely broken stone.

Fig. 39 is a photograph of two semi-detached villas at Paisley, which have been erected with hollow concrete blocks made by an "Ideal" machine supplied by Mr. Matthew Wyllie. The blocks used were all 16 in. long by 8 in. high and 10 in. thick, and panel, cobble, rock face and plain face blocks were used in the construction. The balls on the pillars and the coping were all made in "Ideal" moulds. Every block in the houses is hollow, and the average cost of the blocks made by the builder was 4d. each. The body of each block was made of 4 parts of gravel and sand to 1 of cement, while the face of the block was made of crushed granite and cement in the proportion of 2 to 1. Each house has five rooms and a kitchen. They were built by Messrs. D. Brown & Sons, builders, of Paisley.

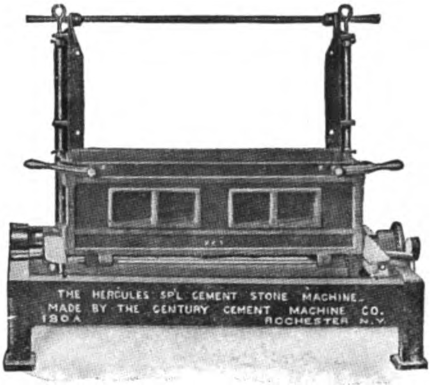

THE HERCULES SP'L CEMENT STONE MACHINE.
MADE BY THE CENTURY CEMENT MACHINE CO.
190A
ROCHESTER N.Y.

FIG. 40. "HERCULES" CONCRETE HOLLOW BLOCK-MAKING MACHINE.

The "Hercules" is an American face-down machine for which Messrs. James P. Corry & Co., of Talbot Street, Belfast, are the agents. *Fig.* 40 shows its construction.

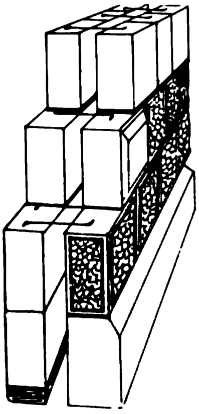


FIG. 41. CAVITY WALL CONSTRUCTED OF CONCRETE BLOCKS. (Showing ties.)

Messrs. Sutcliffe, Speakman & Co., Ltd., engineers, of Leigh, Lancs, contend that hollow concrete blocks do not form a proper weather-resisting cavity wall, and they advocate the building of walls as shown in *Fig.* 41, using iron ties such as are adopted for cavity brick walls. *Fig.* 42 shows their patent combination press for making solid concrete blocks for the construction of such walls. In this machine power is employed with consequent greater output than by hand. With this machine the size, shape and form of the blocks may be varied within certain limits. The largest size block that the machine will make is 20 in. long, 10 in. wide and 6 in. thick; the size recommended is 19½ in. long by 9½ in. high by 4⅜ in. thick, equal to six standard 3 in. bricks including joints. Half and three-quarter blocks, stone-faced headers, door jamb blocks, joist blocks, etc., can be easily made by having different moulds. The machine consists of a revolving table carrying the moulds, working in conjunction with a powerful bell crank lever, operated by a crank and double-geared driving arrangements. The table carries three moulds, leaving a blank space on the table admitting of a free space for cleaning the top die at each revolution should this be needed. The table is rotated by a separate drive from that operating the press, and is started in motion by a suitable clutch gear and lever. The pressing mechanism is operated by fast and loose pulleys and belt gear, set in and out of gear by an arrangement of levers, this gear being so arranged that it is impossible to set the press in motion unless the mould is exactly opposite the die. The moulds are constructed with a loose front which is locked when the block is pressed and automatically loosened when the block is discharged. Thus, to eject the block little pressure is exerted by the machine, the block being quite loose in the mould, and it is pushed out ready for carrying away. The moulds are so distributed that while one is being charged with material the second is being pressed, and the block is being discharged from the third. When working the machine at full capacity four operatives are required: one to actuate the starting levers, one to feed the moulds, one to take blocks away, and one to fix moulds and put in pallets. Such a staff can produce 100 to 200 blocks per hour, depending on their skill. The block is pressed with its face upwards, so that in facing the blocks the facing material is put into the moulds last. The machine can also be used for making sand-lime and concrete bricks or blocks, paving flags and tiles, etc. The weight of the machine is about 8½ tons, and requires about 5 actual horse-power for driving. If desired a hydraulic ram and cylinder can be fitted instead of the mechanical press.

(*To be concluded.*)

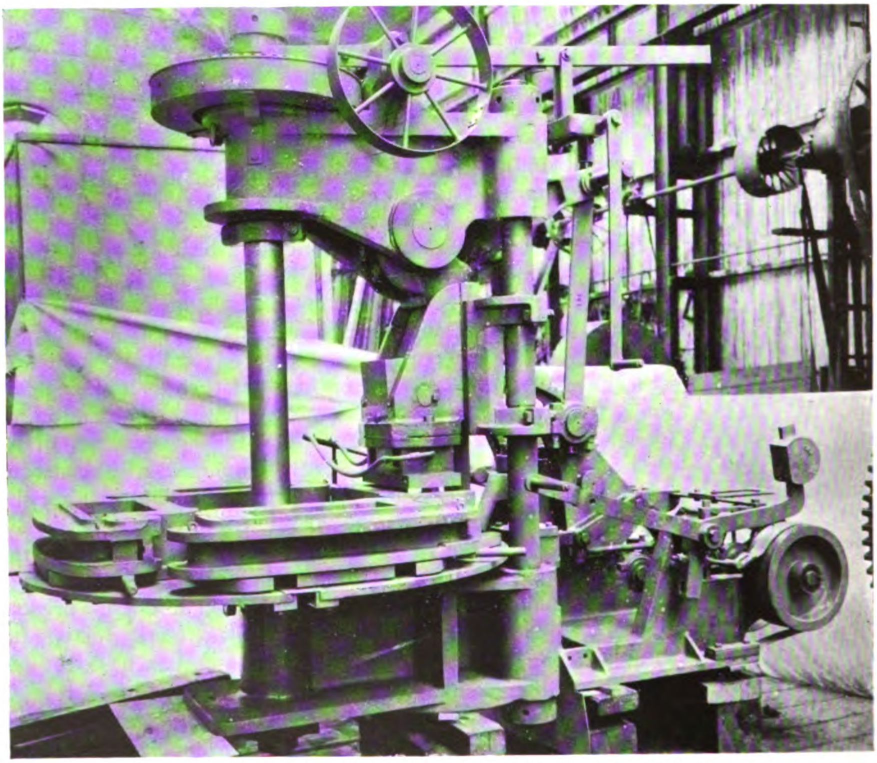


FIG. 42. POWER PRESS MACHINE FOR MAKING CONCRETE SOLID BLOCKS.
(Constructed by Sutcliffe, Speakman & Co., Ltd.)

DON'TS on CONCRETE.

By H. T. DESCH (Surveyor to Messrs. W. Cubitt & Co.).

Errors are so frequently made in connection with the preparation of concrete, that we have thought it advisable to have prepared for publication a series of "Don'ts" as to what should be avoided.

In selecting our author we have asked one who has long been practically engaged in supervising concrete work of varying extent.

These "Don'ts" we publish below, and we shall be happy to receive any further communications or suggestions as to additions to same.—ED.

CEMENT.

1. Don't use natural or slag cement for reinforced concrete work. Portland cement is the only material which is sufficiently trustworthy.

2. Don't use a cement of an unknown Brand when the old-established Brands can be conveniently used.

3. Don't use cement without previously getting a certificate of its soundness and of its having been ground to the necessary degree of fineness. Coarse particles of cement are of no more value than sand.

4. Don't use a cement which requires aeration before it can be used.

5. Don't use cement which has caked through being allowed to get damp.

6. Don't use a cement which will begin to set before the concrete is placed *in situ*.

AGGREGATE.

7. Don't give the selection of the aggregate less attention than the selection of the cement.

8. Don't use large stone or gravel for reinforced concrete work. For floors everything should pass through a $\frac{3}{4}$-in. mesh.

9. Don't measure ballast without screening; it is necessary to know how much is sand and how much gravel.

10. Don't sift the fine particles out of your sand.

11. Don't use coke breeze if it contains dirt or ashes.

12. Don't use a loamy, greasy, or dirty aggregate of any kind.

13. Don't use mixtures of the same richness for all work. Whilst a 1 : 2 : 4 (1 : 6) mixture will do for foundations, 1 : $1\frac{2}{3}$: $3\frac{1}{3}$ (1 : 5) mixture is wanted for floors and columns.

MIXING.

14. Don't use water until the materials are mixed dry, so as to show a uniform colour.

15. Don't use sea water when you can get fresh; and don't use dirty water on any account.

16. Don't add water all at once. Add it gradually until the colour is again uniform.

17. Don't make the concrete so wet that it flows like a liquid.

18. Don't make it so dry that it will not enter between the reinforcing rods and wires.

19. Don't mix more concrete than you can use at one time.

FILLING AND RAMMING.

20. Don't use thin or weak timbering, it is false economy.

21. Don't allow careless ramming, that displaces the reinforcements.

22. Don't ram coke breeze concrete too heavily.

23. Don't add more concrete after one layer has been filled and rammed, without first roughing the surface and pouring on a liquid grout.

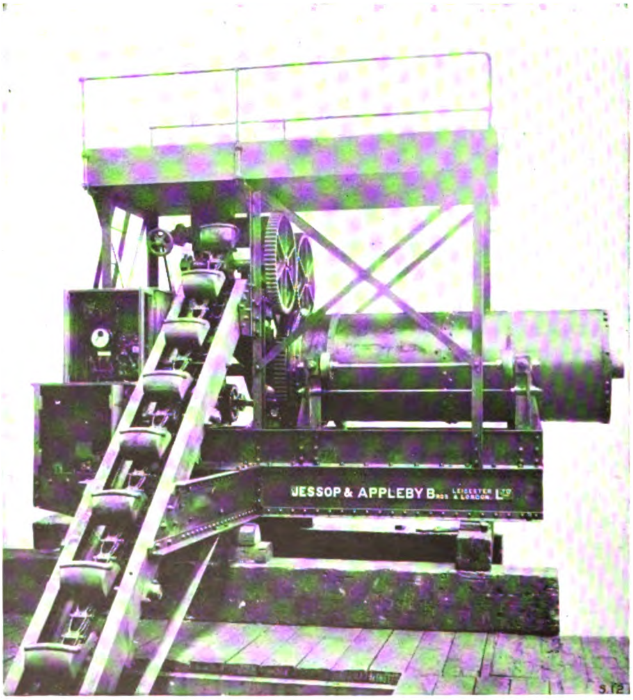
24. Don't leave unfinished concrete work in cold weather without covering it with sacks or felt.

GENERALLY.

25. Don't omit to provide for change of volume (expansion or contraction) when dealing with large horizontal or vertical areas.

26. Don't remove shuttering or other timbering before the concrete has had time to become thoroughly hard.

27. Don't scamp any portion of the work.



CONCRETE-MAKING MACHINERY.
FIG. 5. CAREY LATHAM MACHINE.

CONCRETE-MAKING MACHINERY.

PART II.

By DR. JOHN S. OWENS,
A.M.Inst.C.E., F.R.G.S.

The appliances available for concrete-making or mixing are not fully known, and we are thus publishing three articles dealing with this important subject.—ED.

As my article in the last issue was devoted to a consideration of the principles underlying the making of concrete by machinery, this will be chiefly descriptive of the various concrete mixers in use at present. In order to cover as much as possible of the ground in the space at my disposal the following arrangement has been adopted: the machines are described as far as practicable in alphabetical order according to their names, and the description, as well as giving general particulars, falls chiefly under the heading—(a) method of measuring the materials, if automatic; (b) feeding; (c) mixing; (d) discharge.

It is impossible, however, to include particulars of all the machines now in use or on the market; hence only those which are chiefly used in England are described, together with such others as embody new principles or methods considered to be of importance.

Before going further I should like to draw attention to certain points relative to concrete mixers which should be kept in mind when comparing the relative output of two machines, or the cost of mixing per yard cube. The data which are usually available on these points are useless for the purpose of comparison, on account of the varying conditions under which the machines work. When, for instance, all the materials for concrete are delivered close to, and at a higher level than, the mixer, it is possible to adopt a method of feeding by means of bins or hoppers which will place such a machine in an altogether more favourable position, as to the cost of the concrete turned out, than if the same machine were situated at some distance from, and at a higher level than, the materials. As, however, most of the figures obtainable for output and cost include both the bringing of materials to the mixer and removing the concrete when mixed, as well as the actual cost of mixing, such figures can only be compared when the cost is split up under these heads. When therefore the cost of making the concrete, or the output of the machine, is given, the conditions under which the work was done must be carefully noted.

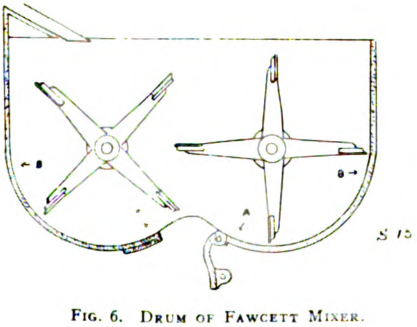
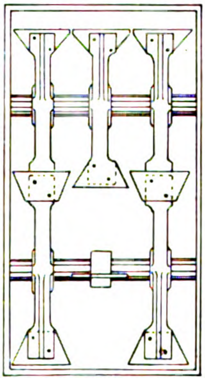


FIG. 6. DRUM OF FAWCETT MIXER.



The Carey-Latham Mixer.—This is a machine of the continuous type. As well as the special machine designed for the Newhaven Harbour Works, previously mentioned, a more generally useful size is made.

The mixing is effected by means of a revolving cylinder, having longitudinal dashboards fixed on its inner surface.

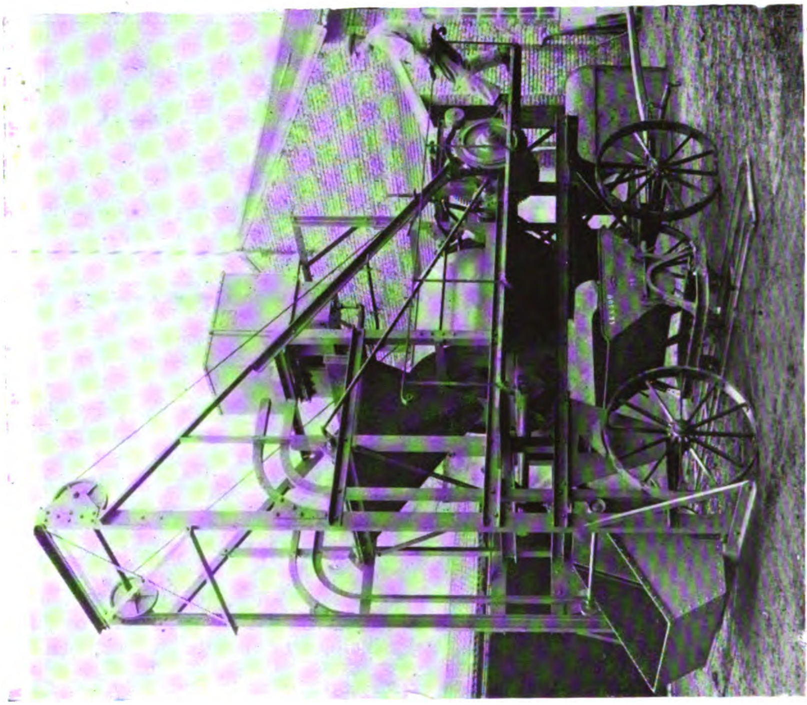


Fig. 8. The Gauhe (Koppels').

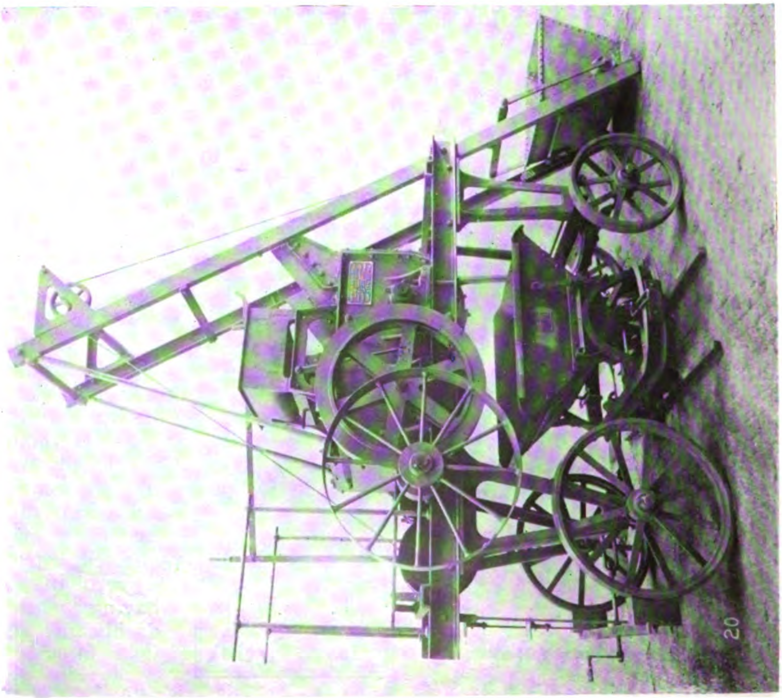


Fig. 7 Fawcett Machine.

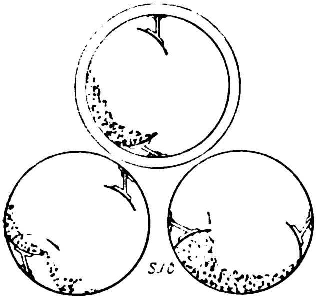


FIG. 9.

This cylinder is inclined towards the discharge end at an angle of 8 degrees. It is fed by means of chain and bucket elevators, one for the sand and one for the gravel or stone. A screw creeper is fitted to feed the cement from a hopper in the required proportions. The cylinder revolves on friction rollers. This machine is shown in *Fig.* 5, which adequately explains its construction; it does not therefore call for further description. The large machine, before referred to, is fully described in the *Min. Proc. Inst.C.E.*, Vol. LXXXVII.

The Chicago Cube Machine.—This is a machine of the batch type, and the following particulars have been kindly supplied to me by the makers :—" Our machine is simply a square steel box with diagonally opposite corners cut away, and to these open corners are riveted heavy grey iron hollow trundles, through one of which the materials are charged while the drum is revolving, and the mixed concrete is discharged through the opposite hollow trundle by tilting the drum up to an angle of about 35 degrees, so that the concrete practically runs out of its own gravity. There is no inside mechanism, such as paddles, shelves or blades, therefore the machine is discharged very quickly and very clean. . . . When the aggregates enter the cube they are at once folded together in one constantly moving mass, and as there are six sides to a cube, and when the cube revolves on an axis passing through diagonally opposite corners, three of these cube sides are on one side of the centre line of revolution, and three on the other side, each individual side alternating with the sides across the centre line, and as the drum revolves these sides carry the materials up and fold them over towards the centre, first one way and then the other, six times in each revolution, and as the entire weight of the whole mass rests on the lower particles the concrete is subjected, not only to a folding over and kneading process, but is subjected to pressure as well, so that every crack and crevice in the coarser particles are forced full of cement paste, insuring actual contact between each and every ingredient used."

In a report of the Chief of Engineers U.S.A. Army, on a machine used by the War Department, the cost of mixing is given as 1·34d. per cub. yd., and the cost of taking the sand, stone and cement from stock piles and warehouse as 7·57d., the total cost being 8·91d.

The Fawcett.—This is a batch mixer in which the mixing operation is performed by revolving arms or paddles acting in a fixed vessel. The mixing vessel or drum (see *Fig.* 6) contains two parallel spindles, each carrying three sets of arms or paddles; there are four arms in each set. The revolution of the spindles is in opposite directions, so that the arms on each spindle approach those on the other at the lower half of their revolution, and recede from them at the upper half.

This has an important effect in aiding the discharge, since the discharging door is at the bottom of the drum, and the revolving paddles scrape out the concrete when the door is opened.

The mixing effected by this machine is of the most perfect character, owing to the thorough kneading and stirring of the materials.

This machine is fitted with an elevator for measuring and feeding the charge, and an automatic water tank for measuring the water. The action of the elevator will be seen from *Fig.* 7. It consists of a single skip, designed to hold the materials for one charge; when filled the skip is made to ascend along a pair of inclined guides by means of a wire rope, which is wound on a drum actuated through a friction wheel. At the top the skip tips automatically into the mixing drum, and is lowered for another charge by releasing the friction gear and putting on a brake to prevent too rapid descent. This elevator works well. The machine is made in four sizes, having nominal capacities of from about 100 to 300 yds. cub. per 10 hours. The weight of the smallest machine with elevator and road wheels is 4 tons; h.p. required to drive 5 to 7. The actual cost of making concrete with the small machine when turning out an average of 90 yds. per 10 hours under favourable conditions was 5½d.

per yd. These figures are the result of observations made on the Worcester Sewage Works, and kindly supplied to me by Mr. Blakemore.

The Fawcett mixer is sent out mounted on high road wheels with a swivelling fore-carriage, so that there is sufficient room for a trolley to pass under the drum to receive the mixed concrete.

The Gauhe (Koppel's.)—This is a batch mixer, and is illustrated in *Fig.* 4 of my last article and *Fig.* 8. The mixing is effected by means of a revolving drum, supported by friction rollers; inside the drum are hung paddles and a scraper, which serve to knead and mix the concrete as the drum revolves. The feed opening is centrally situated at one end of the drum, and the discharge is through a sliding door on the cylindrical part, which is actuated automatically when a lever is moved by the man in charge. The machine is fitted with an elevator, previously described, and an automatic measuring water tank.

Like all machines fitted with rope and bucket elevators, this requires a good deal of head-room, as the height is considerable, from the ground to the highest point being, as before stated, 15 ft. 3 in. The whole machine is, like the one previously described, mounted on high road wheels, so as to permit trolleys to pass beneath the mixing drum to receive the mixed concrete.

The machine works well, and the small size will turn out 80 to 90 yds. cub. per day.

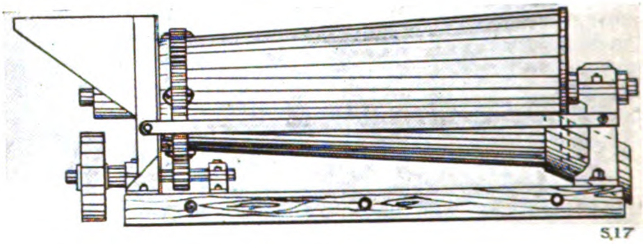


Fig. 10. Mason's Mixer.

The McKelvey Batch Mixer.—This is a batch mixer of the revolving drum type. The drum is a short cylinder of sheet iron or steel, having on one side a central feed opening, and on the other a central discharge opening. A conical hopper is provided on the feed side, and a trumpet-shaped discharge funnel is riveted outside the central aperture on the other side. The drum revolves on friction rollers, and is operated by a chain and sprocket ring. This machine is usually mounted on the same frame with an engine and boiler, so as to make a compact mixing plant. When discharging, the drum does not tilt, but, by means of a small lever attached to the side of the drum, a scoop inside it is made to deliver the concrete through the trumpet-shaped funnel.

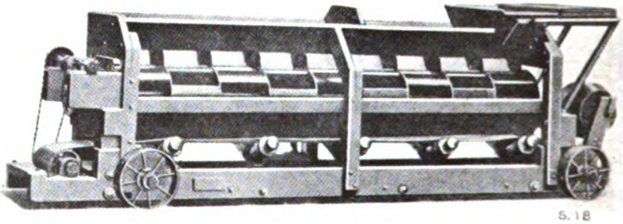


Fig. 11. Nims Measuring Machine.

Special claims are made for the mixing device which is fixed inside these drums, and which is called the "McKelvey Gravity Shovel." It is illustrated in *Fig.* 9, and is thus described :—" It is pivoted to the inner shell of the rotating drum; the top edge, as shown, lies against the rising side . . . and collects the materials in that portion of the drum, and when the shovel is filled the overflow slides rapidly off the lower edge, and the balance is carried upward to a point where gravity causes the shovel to cast it outward and downward, turning it over in the fall."

The machine holding 9 cub. ft. of materials is stated to be capable of producing 7½ yds. cub. of concrete per hour, or 75 yds. in 10 hours.

The Mason Continuous Mixer.—This is a very simple form of continuous mixer, and does not call for a lengthy description. Mixing is effected in a long revolving vessel which is circular in cross-section but wider at one end than the other; hence the materials tend to work towards the wide end where the discharge takes place (see *Fig.* 10). Ribs are fixed inside the revolving cylinder, which does not rest on friction rollers as is usually the case, but has a central spindle passing through it. The machine is fed through a hopper at the small end. The sizes made are from a 7-ft. cylinder with 2-ft. 6-in. mouth, to a 9-ft. cylinder with 3-ft. mouth. The former is intended for hand power, the latter for steam. The makers state that it will mix effectually and rapidly about 80 cub. yds. per hour.

The Mason Pan Mixer.—This is simply a modified mortar mill, in which the rollers are replaced by scrapers or ploughs. It is operated in a similar way to the ordinary mortar mill. The discharge takes place from an opening in one side of the pan. It is made in sizes from a 4-ft. 3-in. pan to a 7-ft.

The Messent.—This is a closed mixer of the batch type. It consists of a vessel of irregular shape revolving on an axle. The shape is specially designed to cause a thorough mixing. The charge is fed into the vessel through a door, with the requisite amount of water; the door is then closed and the vessel revolved about fifteen times, when the motor is stopped and the concrete discharged.

The measuring and feeding for this machine are carried out independently of the mixer by means of suitably arranged hoppers or platforms.

An interesting form of this machine was used on the Dover Harbour Works, where I have seen it in operation. The mixing vessel was of one yard capacity, and was mounted on a steel-framed carriage; this was provided with two electric motors, one of which revolved the mixing vessel, and the other gave a travelling motion to the carriage. The machine having received its charge travelled to the block moulds on specially laid railway lines, and simultaneously revolved its mixing vessel, so that when it arrived over the moulds the mixing was often complete.

As the concrete is not in view in this machine, the amount of mixing required has to be determined by trial, and the number of revolutions noted; a dial is provided to show the number, and thus to indicate when the mixing is complete.

The Nims Concrete Mixer.—This is a rather peculiar machine, since it is stated to act as either a batch or continuous mixer. The mixing vessel is of unusual shape, being somewhat like a pair of cubes interpenetrating diagonally, and revolving on the long axis. The vessel is of cast-iron in one piece, the inside is smooth, and the entire interior is visible; as the materials pass into it they are thrown from side to bottom and from bottom to side again, and so mixed.

A special form of measurer is supplied with the machine, which delivers the materials, by means of a belt, to the mixer. The mixer so fitted acts on the continuous principle, but the makers state that, by fitting an automatic gate to the discharge end, it can be used as a batch mixer, but takes more power and costs more.

The measuring mechanism is peculiar. It consists of a measuring wheel 15 in. diam. and 11 ft. long, revolving under a hopper 12 ft. long (see *Fig.* 11). Each revolution of the measuring wheel delivers, to a belt conveyor beneath, one-quarter of a yard. The hopper has partitions which are capable of being moved to vary the proportions, and the measuring buckets are arranged longitudinally on the measuring wheel, so that, when set for any proportion, the wheel automatically continues to deliver such proportion until again altered.

The makers' claims for this machine are certainly remarkable; they state that the complete plant can be operated by a 5 h.p. engine, and will turn out 600 yds. in 10 hours. I am unable to verify this statement, and give it for what it is worth, but do not doubt that the materials can be put through the machine at the rate stated; whether the mixing would be efficient or not is another question. I need hardly say that this is an American machine.

The Oehler Mixer.—This is a batch mixer of practically the same type as the "Fawcett," previously described, except that its mixing drum is provided with only one spindle, with its paddles, instead of two as in the Fawcett. It is supplied either with or without an elevator, which is also of a type similar to that on the "Fawcett."

This machine is made in two patterns, the "big" and the "small." The "small" has a capacity per batch of 2 or 3 cub. ft. and an output of 20 cub. yds. in

10 hours. The "large" has a batch capacity of 8 to 12 cub. ft. and an output of 75 to 100 yds. per 10 hours. The latter requires a 4 to 6 h.p. engine, the small machine 1 to 2 h.p.

This mixer is made in Switzerland, and is used a good deal in England, especially for reinforced concrete work. The mixing is very efficient.

The Perfect Concrete Mixer (Fig. 12).—This was also illustrated in *Fig.* 3 in my last article. It is a continuous gauging and mixing machine, with one special gauging device for each of the separate materials.

Each device consists of a hopper or receptacle for the material, a revolving feeding drum with deep flanges at each end, and a regulating gate for setting or adjusting the proportions of material.

Each regulator is set by a single lever moving over a graduated quadrant. Each degree on the quadrant indicates a definite quantity passing under the regulator per revolution of the feeding drum; thus the regulators can be set to any proportions. To work the "Perfect" mixer the regulating levers are set to the marks on their respective quadrants indicating the proportions desired, the material hoppers filled, and the machine set in motion. The feeding drums revolve slowly (1 to 2 revolutions per minute). The regulator strikes off the cement and allows a fixed quantity to pass as a layer of uniform width and thickness. This stream of cement falls on a similar stream of sand from the sand drum, and the combined stream of sand and cement falls on the stream of stone or

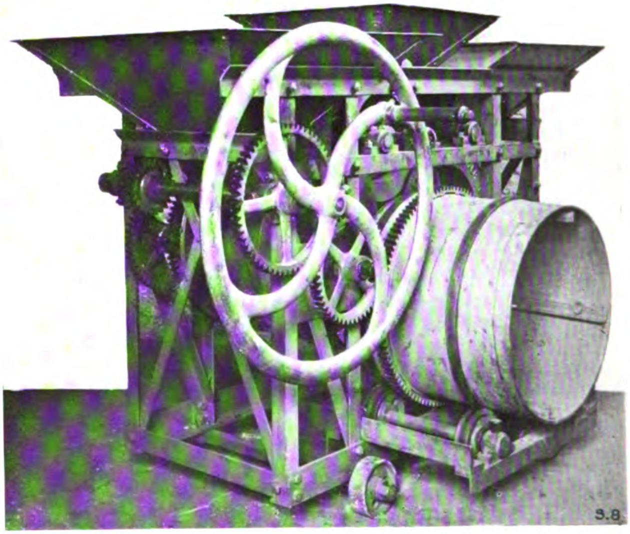


Fig. 12. Perfect Concrete Making Machine.

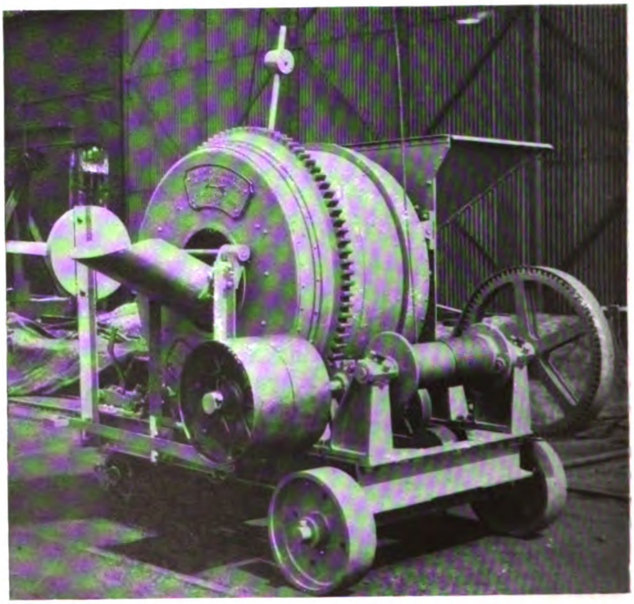


Fig. 13. Ransome Concrete Mixer

gravel from its drum, and thence into the mixing cylinder. It is claimed that little further mixing is required when the materials are delivered into the cylinder. In the latter is a water spray, adjustable as to position, so that there is first a dry and then a wet mixing.

I am informed by the makers that the cost of labour for operating this machine on work at Quenast, in Belgium, is about 1½d. per yd., not including power. The machine is turning out 200 yds. per 10 hours.

The following are the sizes and power required, as given by the makers:—

Capacity 4 cu. yds. per hour. Power required ½ h.p.
Capacity 20 cu. yds. per hour. Power required 1½ h.p.
Capacity 40 cu. yds. per hour. Power required 3 h.p.

The Ransome Concrete Mixer.—This is a batch mixer of the revolving drum type. The mixing mechanism consists of a short cylinder revolving on friction rollers, and having at one side a feed opening fitted with a hopper, and at the other a discharge opening in which works an oscillating shoot. The latter is a special feature of this machine, as by means of it only the quantity of concrete required need be withdrawn from the machine at a time. The drum does not tilt to discharge, but it is effected by simply depressing a lever which operates the shoot.

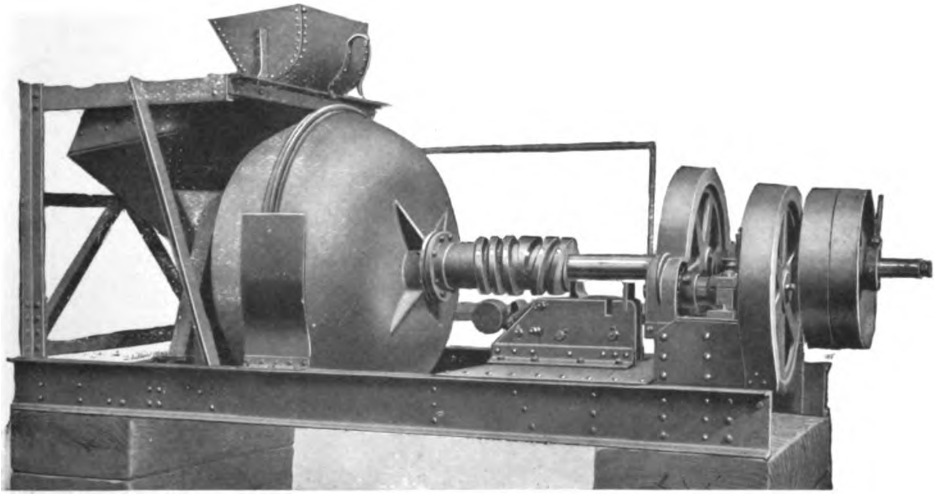


Fig. 15. Roll Concrete Mixer.

Inside the drum are fixed special deflectors which plough through the materials on the bottom, and which have the effect of carrying some up to the top of the drum as it revolves and there discharging such material upon that on the bottom, thus giving a most effective mixing. The machine is well made and will stand rough usage. The water is measured in a special automatic tank and delivered to the drum when desired.

The dimensions of the No. 1 size, which turns out 100 yds. per 10 hours, are as follows:—Drum 4 ft. 6 in. dia. and 3 ft. wide, of $\frac{3}{16}$th in .plate. Working capacity of drum 10 cu. ft. Speed of drum 16 revolutions per minute. Height from underside of frame to top of mixer 5 ft. 7¾ in. H.P. required 6.

When desired, a special gauging elevator is supplied which acts in an entirely novel way. The gauging skip at its highest position when discharging into the drum is only a few inches higher than the top of the drum, hence the whole machine can be moved into positions where a higher mixer could not go. This is a great advantage, especially on reinforced concrete work, as, for example, building floors.

The Roll Mixer.—This is a machine of the batch type which has only recently been introduced into England. Its chief peculiarity is in the nature of the mixing drum; this is a vessel formed of two cup-shaped halves fixed upon a spindle in such a manner as to permit the two halves being drawn apart to discharge the concrete, and closed together again to receive the fresh charge. This vessel revolves about 12 times per minute; it is supported at one side by the central spindle, and at the other by friction rollers under the rim of a central opening, through which the materials are fed. The drum is made of two castings, to one of which is bolted a sleeve carrying a worm, this worm serves to move one half of the drum along its spindle when it is required to discharge.

The machine is mounted on a channel iron frame, and is fitted with an elevator of the type described on the "Fawcett" and "Gauhe" machines; that is, a single measuring skip hauled up by a wire rope. It is supplied either mounted on road wheels or on the frame only, and is made in five sizes from $3\frac{1}{2}$ to 5 cub. yds. output per hour up to 40 to 50; the latter size, however, being very seldom used.

Fig. 15 shows a "Roll" concrete mixer of the stationary type, but without the elevator.

A detailed statement is given in the maker's catalogue showing the cost of running a machine of 12 cub. ft. drum capacity, and 15 cub. yds. output per hour, for a period of 1,600 hours or half a year. In this it is stated that the cost per yard cube of concrete worked out at 4.13 pence, this was inclusive of power; labour (six men); bringing machine to and from yard; interest on cost; repairs and depreciation.

The Portable Gravity Mixer.—This is an apparatus which depends upon the force of gravity to enable it to fulfil its functions. As in all such mixers, the materials must be raised to the level of the hopper of the machine before they can be allowed to fall through. This machine is illustrated in *Fig.* 16.

It consists of a steel trough, which is suspended in an inclined position. This has a hopper at the top, and a chamber at the bottom into which the concrete falls. Mixing is accomplished by means of numerous rows of round pins which penetrate the trough from front to back, inclining downwards towards the back. Adjacent to the sides in the lateral alignment with the respective series of pins are fixed small baffle plates. When the materials are thrown into the hopper they roll down the back of the shoot, and, as each row of pins is "staggered" with respect to the row above and below, the materials in falling are thrown on and off the mixing pins and deflectors and scattered from side to side.

Water is delivered to the trough at about midway in its length, the intention being to allow a dry mixing to take place before the water is added.

This apparatus is made in two forms, a sectional, which allows of use in length from 4 to 10 ft., and a non-sectional form of either 8 to 10 ft. long, which must be used as supplied.

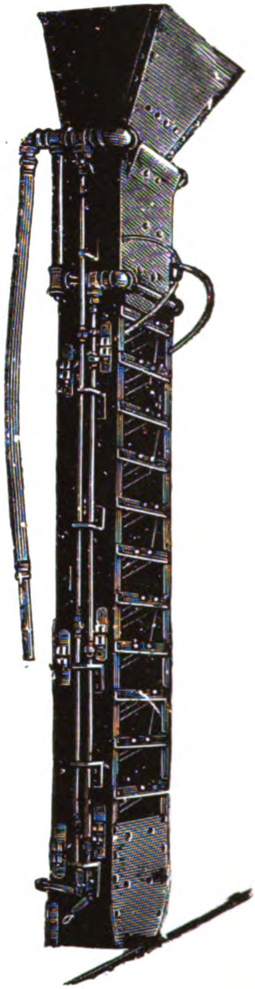


FIG. 16. PORTABLE GRAVITY MIXER.

The Smith Mixer.—This is a batch mixer, and consists of a drum of double conical form, supported and guided by a frame, which can be tilted at will to discharge. The interior of the drum is fitted with rigid blades, arranged in sets in a spiral. The alternate sets are of reversed winding, and overlap each other in the middle of the drum. The drum is supported on a ring, which surrounds it at the greatest diameter, and which in turn rests on friction rollers. A similar toothed ring serves to rotate the drum. Small guide rollers take the weight of the drum when tilted.

The drum is provided with a drip-ring at the discharge end, which prevents the wet material from running down the cone and on to the roller tracks. It is fed and discharged while running.

The mixing process is as follows :—When the materials are fed into the drum the action of the blades and the conical shape of the drum cause a rapid endwise transfer, the materials being passed from each end towards and past the centre of the machine alternately, and at the same time being turned over.

When desired, an elevating hopper is supplied. This is of the rope and bucket type, and is well seen in *Fig.* 17. The skip when resting on the ground is filled with the proper proportion of materials, and is then hoisted to the discharging position by a small winding drum controlled by a spiral friction clutch. A catch is then automatically released, allowing the end door to open, through which the materials pass into the hopper. At the same time the clutch is automatically thrown out and the skip lowered on the brake.

The No. 1 machine holds a charge of 13 cu. ft., requires a 10 h.p. engine, and is stated by the makers to turn out 200 cu. yds. per 10 hours.

(*To be concluded.*)

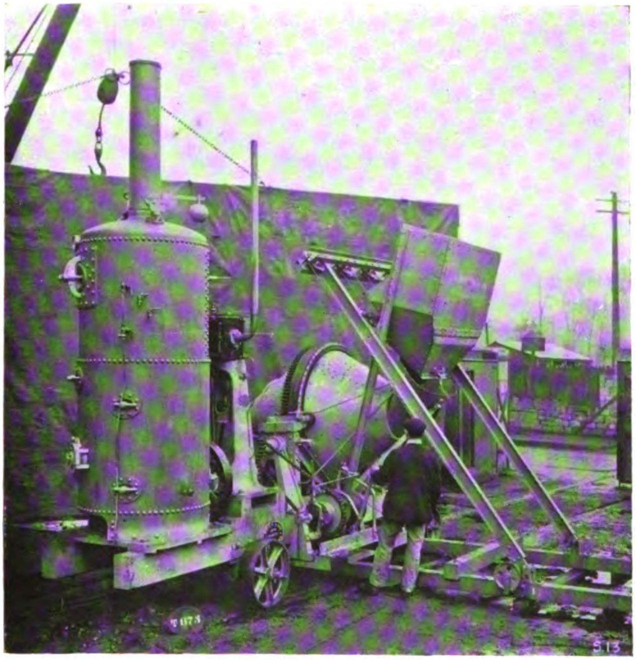


FIG. 17. SMITH MIXER.

NEW USES FOR CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented as to new uses to which concrete and reinforced concrete are put, with data as to experience obtained during the experimental stage of such new applications of these materials. The use of reinforced concrete as a substitute for timber in exposed positions is one of the questions of the moment. Railway sleepers, telegraph posts, fence posts, etc., of concrete are being tried. Similarly, efforts are at present being made to prove that reinforced concrete is an excellent substitute for brickwork, where structures of great height are required.—ED.

REINFORCED CONCRETE PIT-PROPS IN MINES.

THE question of the substitution of an inexpensive and indestructible material for the timber which is at present used in mines is one which is exercising the minds of engineers and mine owners.

We have dealt at some length with the subject in our two preceding issues, and an American correspondent now writes that concrete pit-props in stock sizes are sold by the gross in Colorado. He writes: "On every hand we find the expenses of coal-mining tending to increase. The cost of labour and the cost of supplies are operating against the mining industry, and not the least important of the latter is the cost of the imported timber which is used in such vast quantities by the coal-mining companies of the country. Every extension to the workings of a mine involves an increased use of timber in the form of props and for other purposes. Experiments have been made with reinforced concrete beams, which point to the possibility of using this material largely as a substitute, especially for work which is intended to be of a relatively permanent nature, and in which the increased cost of the concrete beam is justified by its indestructibility and freedom from the decay which overtakes timber. As the cost of timber rises, it is only a question of time when concrete will become a very effective means of construction at the disposal of the miner. At the present time reinforced concrete beams are manufactured and sold to stock sizes for mining purposes in the mining districts of Colorado."

REINFORCED CONCRETE FENCE POSTS.

In earlier issues (Vol. I., page 392) we dealt at some length with the question of making reinforced concrete fence posts as practised in the United States, and took the opportunity of pointing out how easily such posts were made and how practical they were from the point of view of maintenance, inasmuch as they required no repairs and had an exceptionally long life.

It is thus with some pleasure that we hear that the making of these posts of reinforced concrete has at last been started in this country, and that Mr. E. F. W. Grimshaw has taken up the matter and devised some economical forms of fence posts for use in Great Britain.

The general idea of constructing fence posts in reinforced concrete is naturally not one that is subject to any patent or proprietary right, but there are many ways of making such posts, and we understand that Mr. Grimshaw's special method has been the subject of patents, in respect of which he is prepared to grant licences.

We are presenting some photographs of posts made

REINFORCED CONCRETE FENCE POSTS IN COURSE OF MOULDING.

under his supervision, and we understand that they can be made anywhere where suitable aggregate is obtainable, but having regard to their long life they compare very favourably with wood fence posts, particularly in damp neighbourhoods where wood fence posts only too easily rot at the point where they enter the ground.

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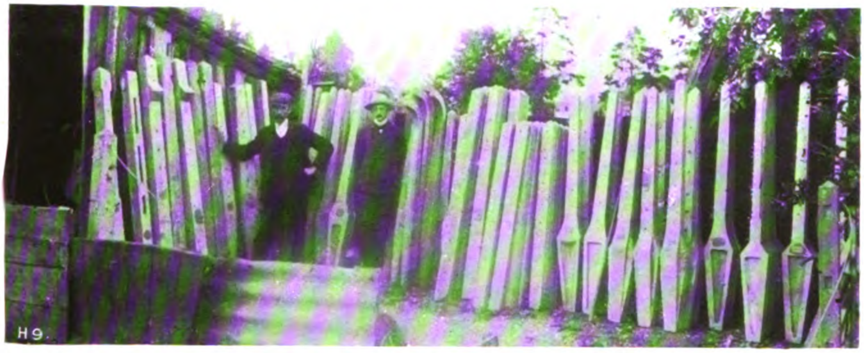
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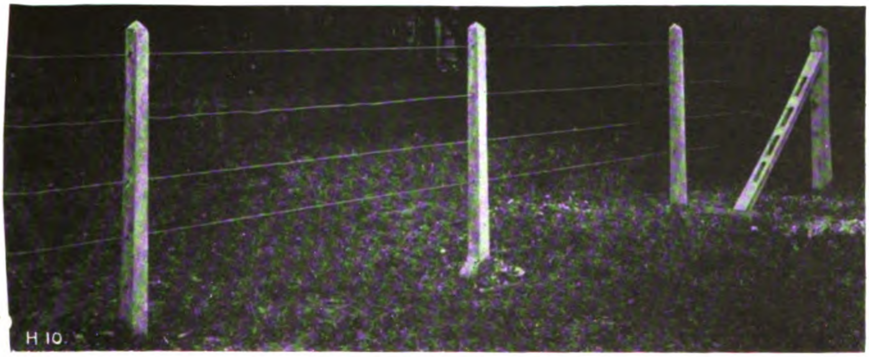
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Reinforced Concrete Fence Posts.

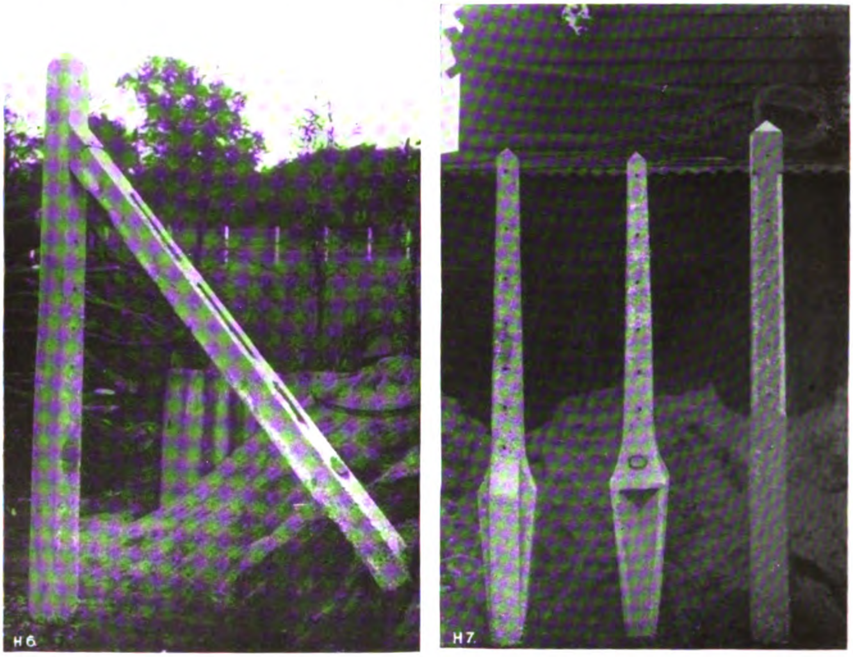
The posts, as in America, are made in moulds and no machinery is required, unskilled labour alone being used. The illustrations explain themselves, and we have made a point of adding one illustration in which the actual process of moulding is shown. Any additional particulars can be obtained from Mr. Grimshaw, of West Mill, Buntingford, Herts.

HOLLOW REINFORCED CONCRETE STANDARDS AND TELEGRAPH POLES.

As indicated in our previous issue, a new process for manufacturing hollow poles of reinforced concrete has just been introduced into this country by Messrs. Siegwart, Ltd., the Cubitt Concrete Construction Company having installed the necessary plant.

The principle that has been worked upon is entirely different to the customary method of manufacturing concrete—namely, by casting it in a mould and allowing it to harden therein. The material is used in a plastic way very much like clay or paper pulp, for by his process of wrapping the concrete round a core no moulds are required to give it shape and form.

We thus propose dealing with the process of manufacture of the poles in detail, remarking that the necessary plant can be easily erected wherever it may be most conveniently located, and that it does not require any great accommodation; the plant is also of a nature that allows of its easy removal from point to point.

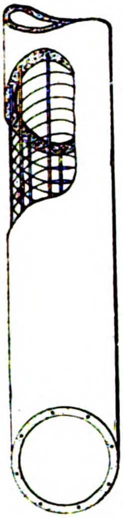


Reinforced Concrete Fence Posts.

The photograph shows the general arrangement of the machine for manufacturing poles. This view shows how the machine is placed, resting in an open concrete pit sunk in the ground, with a track on either side, upon which trestles can be run, and a stage over the machine carrying a concrete mixer which discharges into a receptacle below on the machine itself.

The first machines that were built travelled along a track, while the pole remained stationary as regards longitudinal movement. This, the first machine to be erected in this country, is the first to be built to remain stationary while the core is moved longitudinally (as well as rotating on the trestles before referred to). By moving the core instead of the machine, difficulties of feeding the latter with concrete are overcome, and many minor advantages obtained.

The hollow space in the interior of the poles is formed by means of a core of sheet iron, which is removed after the concrete has been applied to it, the process of removal being made possible by an arrangement whereby the diameter and circumference of the core is reduced by an internal mechanism. Gauge rings are arranged on the core at suitable distances from each other, and steel rods or wires of small



Reinforcement for Reinforced Concrete Standards.

section are passed through holes in these gauge rings, and arranged to lie longitudinally upon it. The wires are stretched tightly by means of hooks that are screwed up at the ends of the core. Upon the track two trestles are placed and the core is mounted between them so as to be capable of rotation therein. The trestles have toothed pinion wheels, which engage with a rack on the track, and are drawn gradually along in the direction of the machine by means of a wire rope that is wound up by being geared, so that the core passes through it at the right rate of progression.

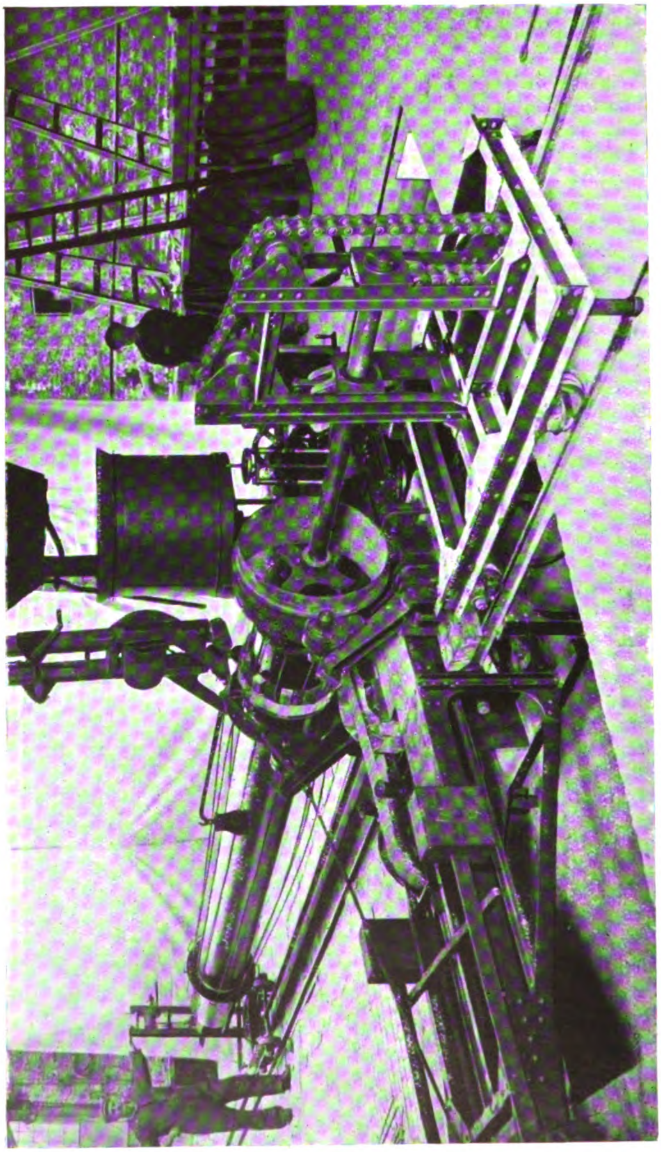
The concrete used in the manufacture of poles is made of cleaned screened Thames grit, which mostly consists of sand, with occasionally small stones not larger than ½ in. maximum diameter, proportioned 3 to 1 of Portland cement, the brand favoured being "Ferrocrete," which is a cement made by the rotary process by the Associated Portland Cement Manufacturers, Ltd. The concrete is mixed very dry, so that it only feels moist to the hand, and does not even stick together when pressed in the hand. It coheres in the manufacture by reason of the great pressure which is applied to it.

The mixer on the stage above has paddles which rotate and thoroughly churn up the ingredients in an open box that can be tipped over to discharge its contents into the hopper below. The concrete falls from the hopper into a sheet metal drum, which stands at the back of the machine. This drum holds a considerable quantity of concrete—namely, about 8 cub. ft., which is sufficient as a rule to make one pole. It is important in the manufacture that the concrete should be fed regularly and continuously, and the drum is arranged to do this, for it slides up and down a sort of oblong box or shoot, so that the surface of the concrete within the drum is always level with the top of this shoot. Four paddles rotate within the drum and scrape the surface of the concrete into this shoot, and the drum is geared so as to rise gradually as the concrete is used, thus always keeping the concrete level with the top of the shoot and enabling the paddles to scrape the concrete regularly and continuously down the shoot. The rate at which this drum rises can be regulated so that the quantity of concrete discharged is greater or less according to the thickness of the layer of concrete which is to be applied to the core.

The concrete is applied to the core by means of rotation, which is quite a novel principle. The concrete from the drum falls down the shoot above referred to, upon a conveyor band or belt made of strong steel wire tightly plaited that takes one wrap round the core, and is given its motion by passing over two wheels. One of these wheels (that at the front of the

Reinforced Concrete Telegraph Pole.

machine) is mounted in a sliding carriage that receives preliminary adjustment by means of a long screw turned by a spoked hand-wheel at the back of the machine. By means of two heavily-weighted levers the sliding carriage applies a pressure of about 5,000 lb. to the conveyor-belt, so that the concrete is wrapped upon the core under this pressure. Upon the conveyor-band is a chain-like device, which affords a grip for a band of strong cloth webbing about 4 in. in width, laid on top of all. The concrete falls upon this webbing, and the webbing and the concrete are wrapped round the core in a continuous spiral, so that the pipe or pole issues with a bandage round it. The edges of the webbing just overlap so that the concrete layer thereunder and the webbing are continuous, the latter so preventing the concrete dropping from the core. The pressure on the conveyor-belt draws the longitudinal wire or rod reinforcements closer together. The guide rings holding the longitudinals in position are engaged by a wheel attachment, so that they slide along the rods as the core gradually passes through the machine. Sometimes there is only one guide ring, when only one grooved wheel to engage it is brought into service, but at other times, such as when making long poles, two guide rings are employed, and a second grooved wheel is brought over to engage with the edge of the guide ring and stop it from travelling with the core.



Reinforced Concrete Pole "Weaving" Machine.

Immediately the webbing and concrete issues beyond the conveyor-belt, wire or wires, as close together as may be desired, are fed by a spool on the attachment somewhat resembling an elevator. The webbing is drawn up over a bar above this spool of wire, so that the wires for the spiral binding may be fed upon and into the concrete. A rod fastened to this elevator attachment keeps it rigid, and the rotation of the core draws the wire or wires from the spool so hard against the layer of concrete that they penetrate into it for some distance. If these spiral wires are of large section, the power developed is insufficient to draw them into the layer of compressed concrete, therefore another device is brought into action, consisting of a wheel with spikes thereon that cut grooves in the concrete as the core rotates, into which the wires may penetrate so as to become embedded in the concrete. The rotating core draws the band of webbing upon the surface of the concrete again, and a pressure roller on the end of a long spindle, which is screwed forward by hand, presses this webbing and the concrete hard against the core, in order to give it a maximum hardness. The thickness of the layer is, by the great pressure given by this roller, slightly reduced, and the resultant reduction in diameter and circumference means that the quantity of webbing that was originally fed into the machine is now too long, but the slack is taken up by the elevator attachment above referred to, which is suspended by means of a wire rope running over a pulley on the platform above having a weight hung from the end thereof, this arrangement enabling the elevator to gradually rise as the amount of slack in the webbing increases. A final finish is given by the sheet-iron ring smoothing the layers of webbing and concrete.

The electric motor that works the machine is mounted on the bottom frame, and the driving is by means of a worm wheel and several chain wheels. The machine can be adjusted to the necessary angle to the core if tapered, such as in the case of a post.

As soon as the core has been drawn through the machine completely wrapped with the spiral binding, it is picked up by a travelling crane overhead and slung on one side to enable the concrete to harden and mature. To ensure it gaining maximum hardness it is constantly wetted.

The interior sheet metal core can be removed by being reduced in diameter by the screw attachment within after about 12 hours, and the bandage of webbing may be removed after three to four days' hardening. This webbing leaves a few small markings, which are no detriment for a pole erected in a place where appearances are not of great importance, such as in the country. To complete a pole, all that requires to be done after it comes from the machine is merely to fix a stopper in the top and make a square necking or blocking for fixing the cross-arms that carry the insulators and the electric wires. The former is cast in a mould and dropped into the top of the post; the latter is moulded by hand. Where a more finished appearance is desired, the poles are given a wash of cement grout or rendering of cement and sand, the latter giving a stone-like appearance, and if desired neckings or mouldings may be run round the pole and any other ornamentation done by hand; indeed, the Siegwart pole can be made very decorative, and although it is a little greater in diameter than an iron pole, this really gives it a better appearance, as the proportion is better.

A diagram is shown of the arrangement of the reinforcement and details of the construction of a typical Siegwart pole. It will be seen that the reinforcing skeleton consists of longitudinal rods tied together by a wire or wires wound spirally thereon. It is important in such tubular construction to have the reinforcement correctly disposed, and the Siegwart process ensures every control over their position and accurate placing, whereas in the ordinary process of moulding concrete in tubular form, grave defects in this respect are of common occurrence, it being extremely difficult to ensure regularity in the disposition of the reinforcements. The process has the ordinary advantages attached to it of additional reliability given by factory labour, specialisation, and organisation.

The longitudinal reinforcements in the Siegwart pole are made in one length continuous from top to bottom, but in the pipes several rods, shorter than the total length of pipe, are often used.

The thickness of the concrete varies from 1 to 2 in. in the poles, but the pipes vary from ¾ in. to 2 in. in thickness.

NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

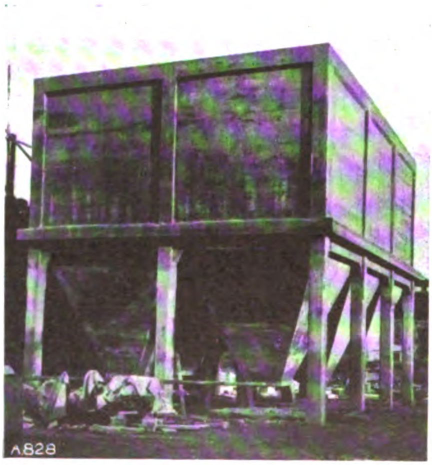
Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED

REINFORCED CONCRETE GRAIN SILO AT RUGBY.

THE reinforced concrete Raw Meal Silos, at Messrs. Kaye & Co.'s Works, Southam, Rugby, illustrated on this page, for which Mr. W. Gilbert, M.Inst.C.E., of London, was engineer, were constructed by the New Expanded Metal Company, Ltd., of Westminster, on their system. The reinforcement consists chiefly of Expanded Metal (steel) with round rods and Indented Bars; the Expanded Metal in the column footings, bins and roof—round rods being also used in the bins—with Indented Bars in the columns.

The bins, six in number, are 12 ft. 6 in. by 11 ft. 6 in. inside, each having a carrying capacity of 60 tons, the complete nest being 40 ft. 6 in. by 26 ft. by 30 ft. above ground line. The columns are 14 in. by 14 in. throughout; the outside columns rest on footings 5 ft. by 5 ft. by 9 in. thick, reinforced with two layers of No 68 Expanded Metal near the underside, and the two inside pairs rest on footings 10 ft. by 6 ft. by 9 in. thick, with two layers of No. 68 Expanded Metal near the underside and one layer between the columns near the topside. The hoppers are 8 in. thick at their junction with the walls to 6 in. thick at the mouth, and are reinforced with one layer of No. 68 Expanded Metal and round rods; the rods are threaded and left projecting beyond the concrete to carry the cast iron mouthpieces, the outlet being 1 ft. 9 in. by 1 ft. 6 in. The walls are 8 in. thick at the bottom to 6 in. thick at the top, the external walls having one layer of Expanded Metal near the outer face, and the division walls one layer near each face, distanced by small round iron dogs 18 in. apart; No. 62 Expanded Metal being used for the lower half of the height, and No. 10 being used for the upper half of the height. The roof is 6 in. thick and is reinforced with No. 10 Expanded Metal, and over each bin is inserted a manhole frame and cover for inspection purposes, a filling hole 10 in. by 10 in. being left at the centre of each bin.

REINFORCED CONCRETE ROOF TO SAIL-MAKER'S LOFT.

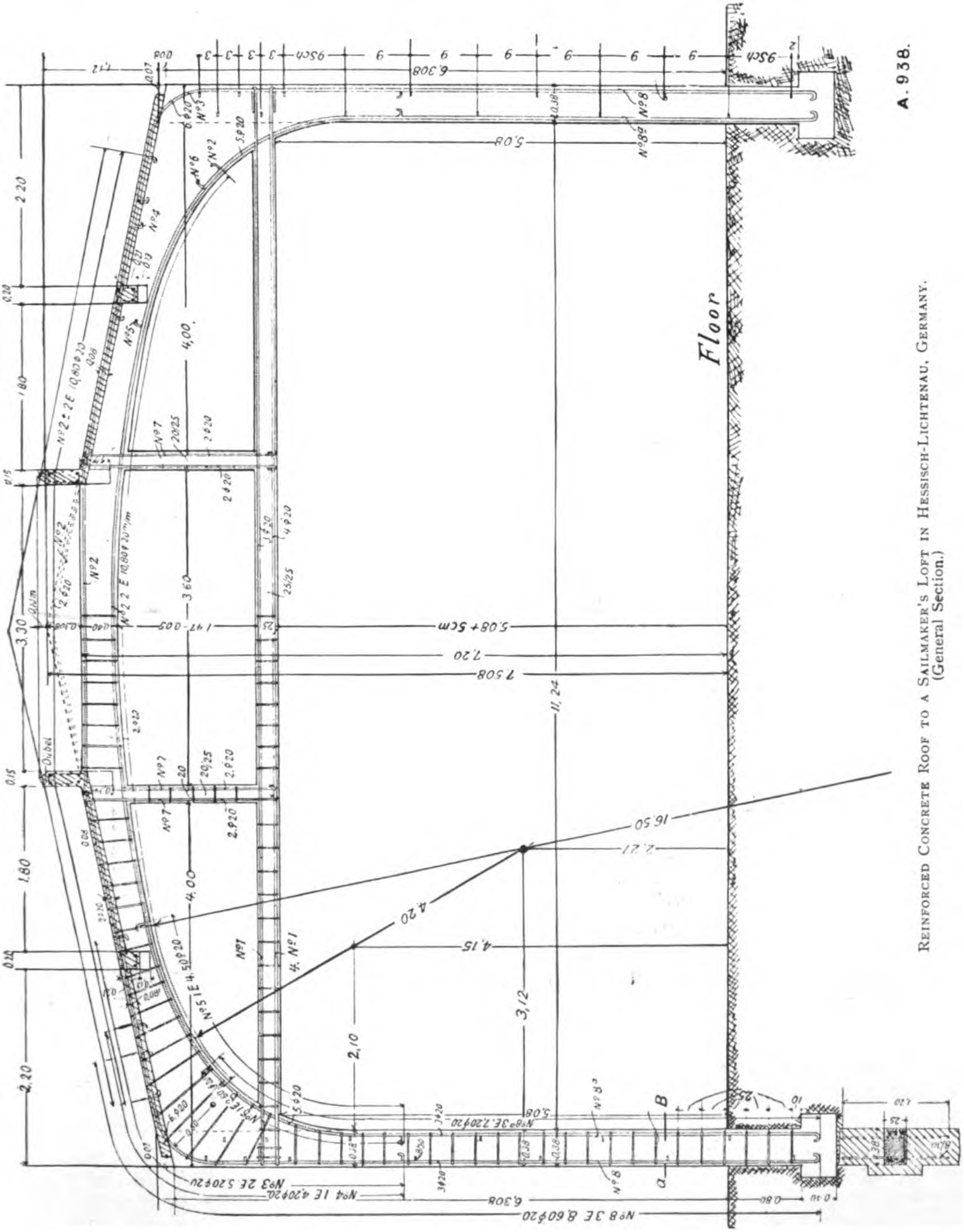


REINFORCED CONCRETE GRAIN SILO FOR MESSRS. KAYE, RUGBY.

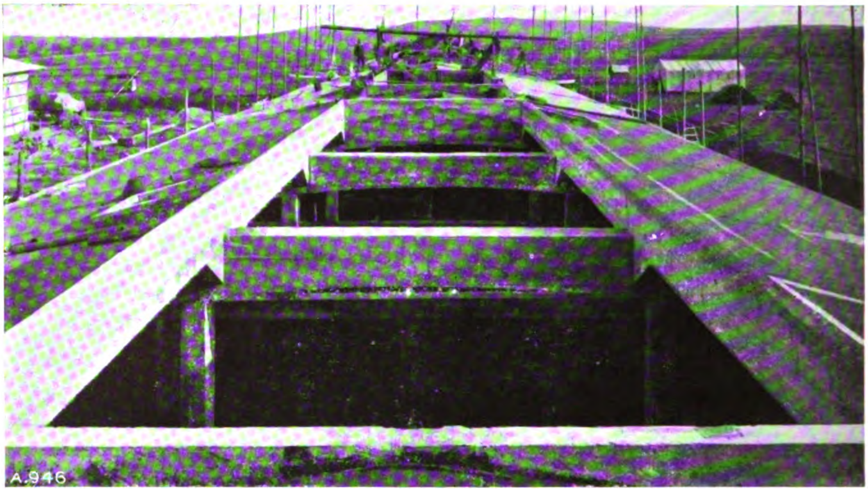
THE roof that we illustrate has been constructed in Germany, in Lichtenau, for the sail-making works of Messrs. Froelich & Wolff, and certainly merits attention, having regard to the industrial requirements of the day to provide works with large lofts or workshops that do not require the interminable expense of constant painting and repairing.

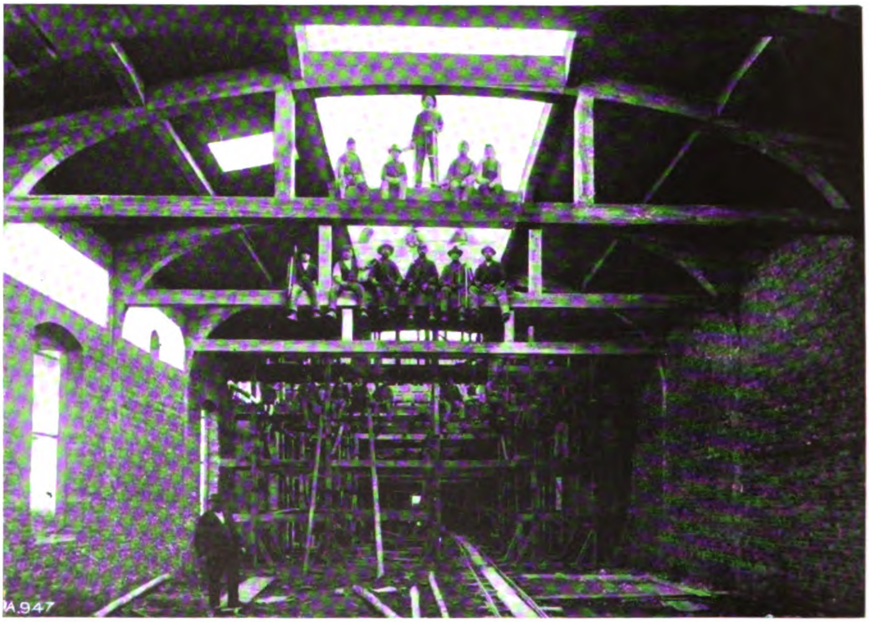
We are indebted to the architect for the photographs presented, and also for certain plates which have appeared in our contemporary, *Beton und Eisen*, and from which we have prepared the diagrams illustrated. These diagrams practically explain themselves, especially as they are figured in detail, and the only general observation we would make is that the loft has a length of 60 metres by 12 metres, or, roughly, 200 ft. by 38 ft., and that the roof girders not only carry the roof, but a considerable amount of machinery.

As will be seen, the roof has large top lights, and perhaps we should also add that it was constructed in three sections with an expansion joint between each section.



Reinforced Concrete Roof to a Sailmaker's Loft in Hessisch-Lichtenau, Germany.
(General Section.)



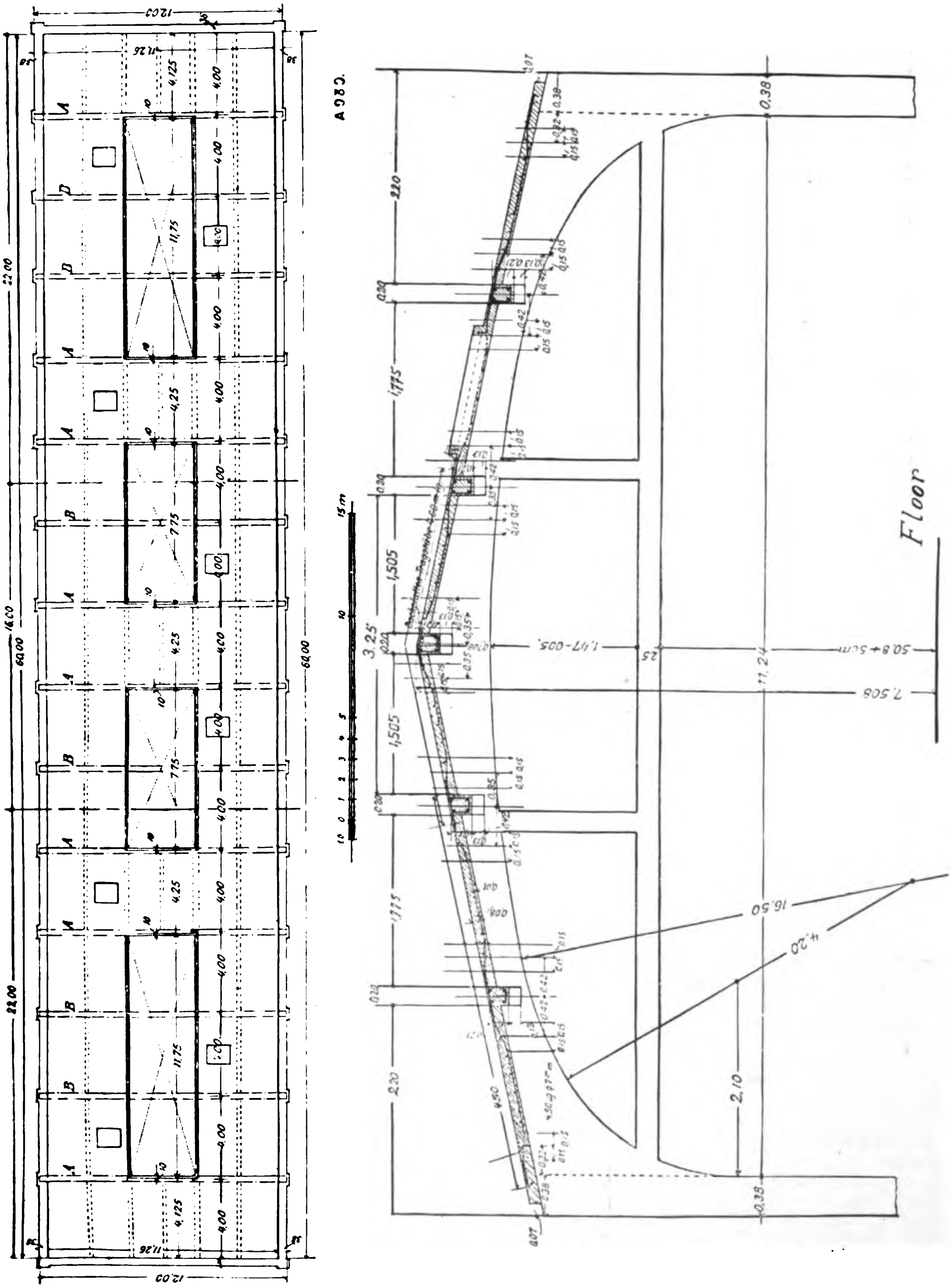


REINFORCED CONCRETE ROOF TO A SAILMAKER'S LOFT IN HESSISCH-LICHTENAU, GERMANY.
(Top and Interior Views.)

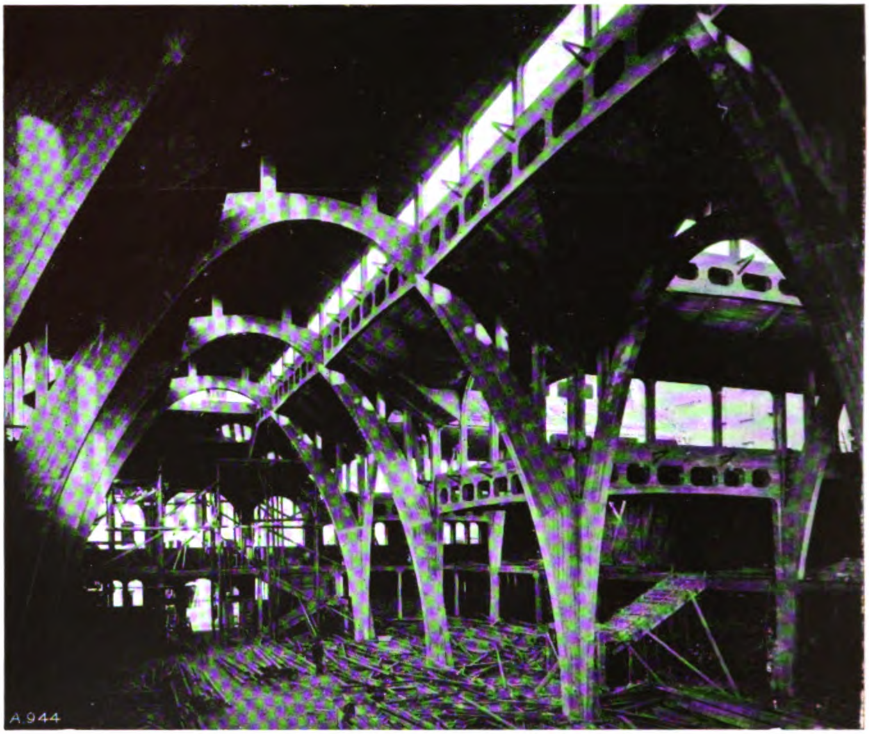
The architect of the work was Mr. Kormann, of Cassel, and the execution of the reinforced concrete structure occupied six weeks.

REINFORCED CONCRETE MARKET HALL.

THE new Market Hall for the town of Breslau, Germany, has been constructed entirely in reinforced concrete, including the architectural rendering, which was moulded simultaneously with the concrete of the main members. By the courtesy of Messrs. Carl Brandt, of Breslau, we are able to reproduce two interesting photographs, one of the interior, the other showing the arrangement of the forms and centering required.



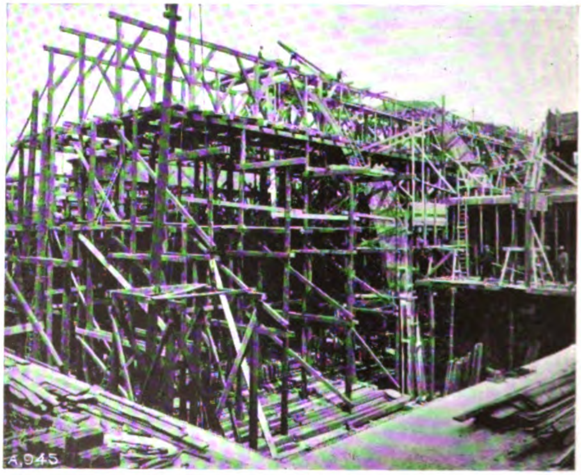
REINFORCED CONCRETE ROOF TO A SAILMAKER'S LOFT IN HESSISCH-LICHTENAU, GERMANY.
(Plan and Section.)



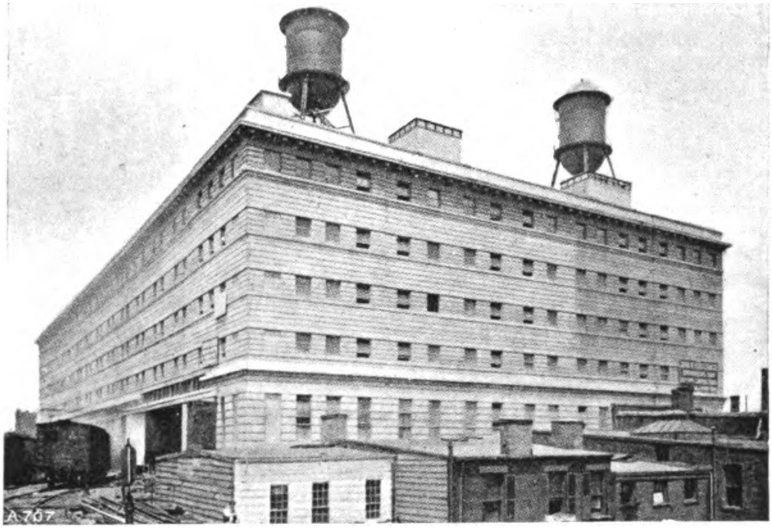
Reinforced Concrete Market Hall in Breslau, Germany.
(Interior View.)

The floor area covered in is 36,000 sq. ft. and at a height of 15·5 ft. above the floor, galleries of 20 ft. width run on all sides of the building, furnishing an additional floor space of 16,000 sq. ft. The main hall is 282 ft. long, and the main arches have a span of 62·3 ft. between column footings. The arches are placed at about 40 ft. centres, and have a rise of 55·2 ft. On one side of the main hall there is also a small extension of a width of 22 ft. constructed of reinforced concrete and covered by a flat roof of wood and concrete, and on the other two reinforced concrete extensions arched in section, each 39 ft. wide and 56 ft. long.

The longitudinal girders are designed as trusses with vertical posts and no diagonals, and they can be seen in the view of the interior. Four staircases of reinforced concrete lead up to the gallery, and two service lifts are provided.



Reinforced Concrete Market Hall in Breslau, Germany.
(Showing Centering.)



REINFORCED CONCRETE WAREHOUSE, NEWARK, N.J. (General View.)

A BIG REINFORCED CONCRETE WAREHOUSE.

The Newark Warehouse Co., a subsidiary company of the Central Railroad of New Jersey, have erected a large reinforced concrete warehouse in Newark, N.J.

The building measures 357 ft. by an average depth of 145 ft. and is 102 ft. high. The ground area covered is 52,000 sq. ft., and a floor area obtained is 370,000 sq. ft. It occupies the whole of a rectangular city block just between the point at which the Central Railroad of New Jersey tracks into Newark Cross over the main line of the Pennsylvania and Broad Street terminal station in Newark.

The warehouse has six floors and basement. The first floor is the "van floor," the second the "railway track" floor; the third, fourth, fifth, and sixth are storage floors.

The building comprises a combination of steel frame construction with a concrete covering and reinforced concrete constructed on fire-resisting lines. The external walls are steel frame and concrete, and the foundations of steel beam grillage work with concrete. The floors are of metal plate and reinforced concrete designed to carry 300 lbs. per sq. ft. throughout, and 500 lbs. per sq. ft. in certain parts. The partitions are steel frames and hollow porous terra-cotta slabs. All partition openings are protected by automatically closing fire-resisting doors.

REINFORCED CONCRETE WAREHOUSE, NEWARK, N.J. (Side View.)

SOME RECENT TELEPHONE EXCHANGES

In the construction of buildings used as telephone exchanges it is a *sine qua non* that the structure should be fire resisting. However disastrous a fire may be in any private or public building, the damage caused is to a great extent localised and confined to the building itself, whereas, should a telephone exchange be involved, and the fire be at all serious, an entire nerve centre of public communication is affected and disorganised. This has been brought home to the general public very forcibly by the recent conflagration in Paris, where the exchange was completely gutted and the service generally much interrupted.

Having regard to the interest awakened by this Paris fire, we present some particulars of recent telephone exchange buildings constructed in London for the National Telephone Company, and upon which Messrs. D. G. Somerville & Co., of Westminster, London, S.W., have acted as specialist designers and contractors for the whole of the constructional steel and reinforced concrete work. The first of the four dealt with by this firm was erected at Brixton, and the other three at Paddington, Hammersmith and Deptford respectively.

The general design of these buildings consists of a steel frame built up with riveted stanchions, girders and roof principals, all rigidly bolted and riveted together. The main stanchions are embedded in the thickness of the outer brick wall, and the remainder of the steel, where exposed, cased in reinforced concrete, the thickness of the concrete in no case being less than 2 in. over extreme dimension of steel.

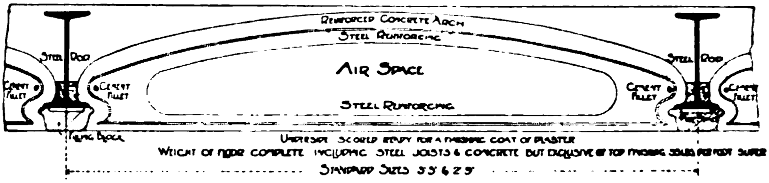
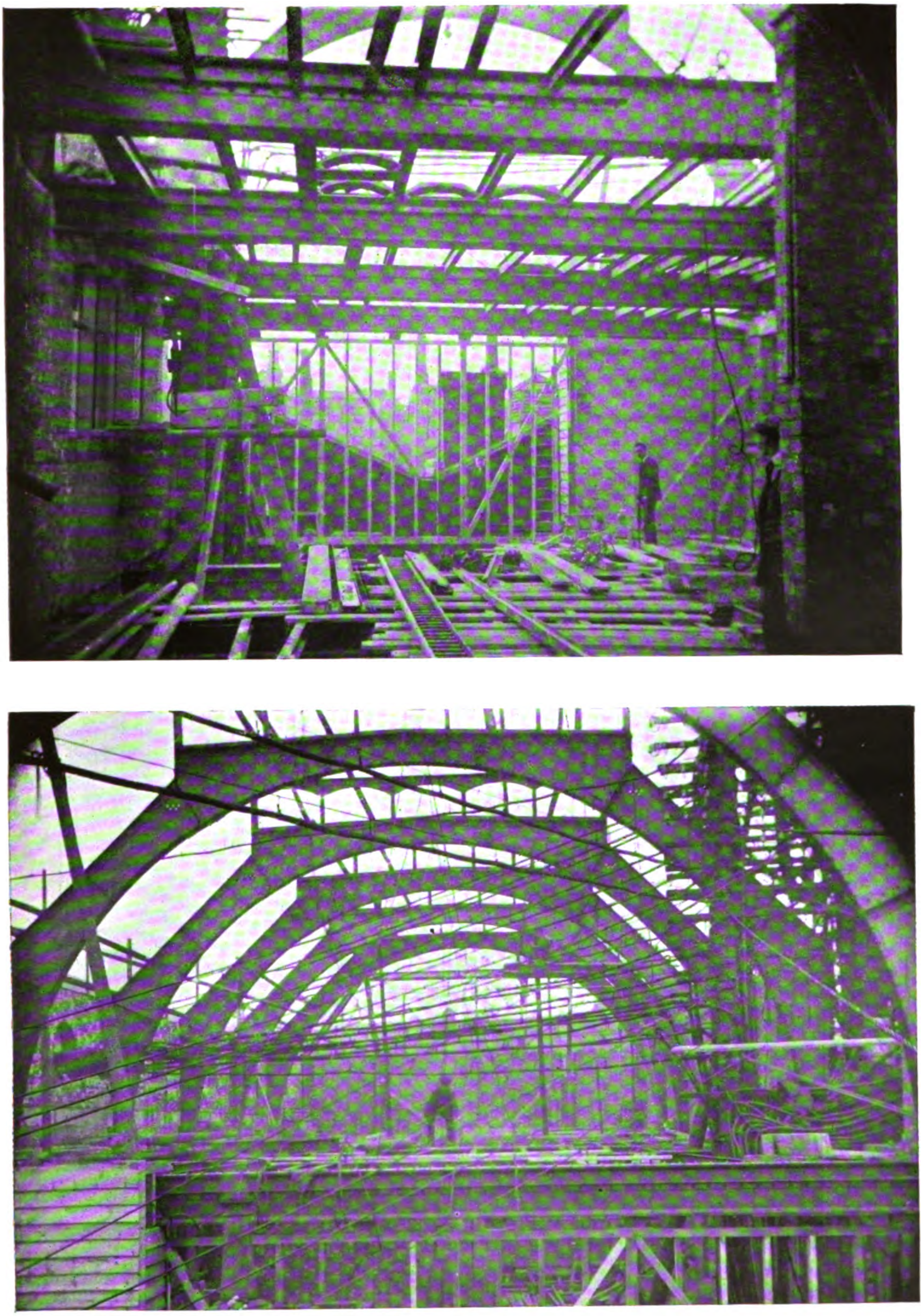


Fig. 1.

In the calculations for the steelwork and floors, each floor has to be specially considered. The ground floor is usually employed as offices and light stores, and the superimposed load taken at $1\frac{3}{4}$ cwts. per sq. ft. The first floor supports the apparatus comprising the motor generators, motors, coil racks, power boards, batteries, etc. Most of these machines being concentrated the load on the floor is to the extent of 6 cwts. per sq. ft., and allowance has also to be made for taking up the vibration of the running machinery. The second, or top floor, supports the switchboard frames through which calls are taken; the platforms are built in narrow sections around the entire floor, leaving the centre free for the operators. The load on this floor averages $2\frac{1}{4}$ cwts. per sq. ft. It is essential that the roof to the top floor (or switchroom as it is termed) should be in one span, and so arranged as to give the maximum of light to the switchboards as well as ample head-room. The roofs themselves support the cable gantries, from which the telephone wires radiate in all directions.

The system of flooring adopted for these exchanges is Messrs. D. G. Somerville and Co.'s hollow reinforced concrete tiles. Small bearer joists, of sufficient depth and strength to support the various loads are placed between the main girders, and the reinforced concrete tiles fixed between these joists resting on the bottom flanges. The surface is then concreted over with fine clinker concrete well rammed into the haunches of the tiles, and the surface finally levelled off to receive wood block flooring. The underside of the tiles projecting below the bottom flanges of the bearer joists forms a level ceiling ready scored for plaster, and intended to protect the steel joists by means of an air space and projecting concrete flange. Many hundreds of wires and cables run through the different floors connected with the various apparatus, and these are passed through the tiles by means of small holes punched where required and grouted in.

Fig. 1 shows the flooring system adopted. *Fig.* 2 illustrates some typical main floor girders in position at the Paddington Exchange, with small bearer joists



FIGS. 2 AND 3. TELEPHONE EXCHANGE AT PADDINGTON, LONDON.

between, and the reinforced concrete tiles being fixed to form the floor. Fig. 3 shows the main roof trusses, and interlaced, a number of telephone wires which were eventually collected and raised to the roof gantry without interfering with the public service. The telegraph pole on the right was on the site of the original building, and was built in as the building was erected, and only removed when the roof was completed. The riveted roof principals, owing to the large span and the heavy load to be carried, are of massive construction, and weigh $5\frac{1}{2}$ tons each, the total weight of steelwork in the building being 350 tons.

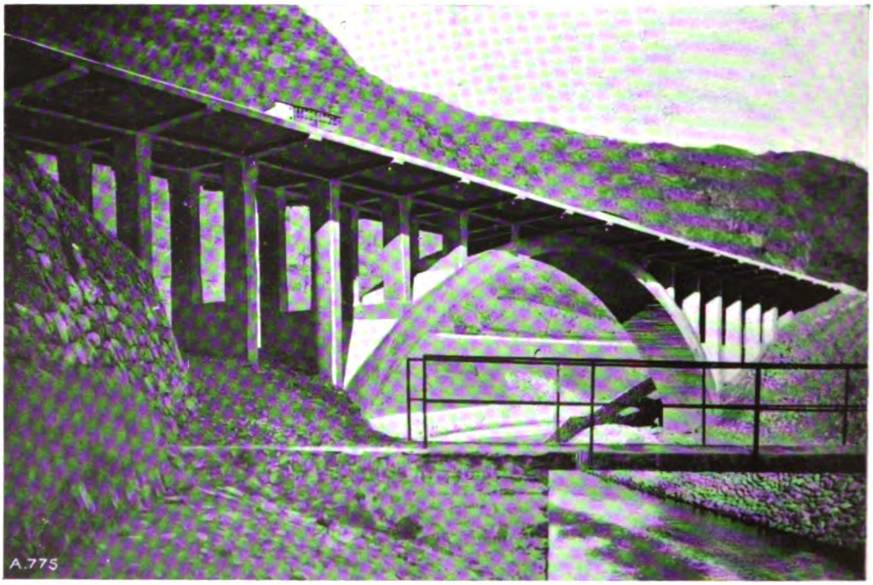
The covering to the roof is constructed entirely of hollow reinforced concrete blocks of similar description to the floors, the outside being asphalted. The dead weight of the roofs and floors, although considerable, is extensively reduced by the hollow system of flooring, which weighs only 35 lbs. per sq. ft. The various floors are also rendered sound-proof by the hollow spaces formed by the concrete tiles.

The other three exchanges are constructed on similar lines and practically only vary in capacity.

AN ITALIAN BRIDGE.

In our issue of March, Vol. III., No. 1, we dealt at some length with the subject of recently erected reinforced concrete bridges to be found on railway and light railway work in Italy.

We pointed out how the bridge work in reinforced concrete was developing in that country, and we are now presenting a view of a further bridge. This one crosses the Conti Canal for an electric railway company. It was constructed by Signor F. Leonardi, of Milan.



BRIDGE ON THE CONTI CANAL FOR THE BREMBANA VALLEY ELECTRIC RAILWAY.

CORRESPONDENCE.

Under this heading we invite correspondence.

REINFORCED CONCRETE RAILWAY SLEEPERS.

By a Correspondent.

There are some apposite remarks in the July issue of Concrete as to how the apparently high cost of railway sleepers of reinforced concrete in comparison with timber sleepers is to be viewed by the permanent way engineer, but it is to be feared that they will not carry home conviction unless proved by figures.

For this purpose let it be assumed that the cost of the timber sleeper is 4s. 6d. and that of the concrete sleeper exactly 50 per cent. more.

As regards life, a well creosoted Baltic redwood sleeper in a properly drained road bed may be assumed to last, say, 12 years. For the concrete sleeper it has been claimed that it is everlasting, as it improves with age, but without taking such a sanguine view, a good case can be made out for the concrete sleeper even if it only lasts, say, 24 years in service.

Following the methods of calculation set forth in Mr. William G. Raymond's recently published book on the "Elements of Railroad Engineering," and assuming money to be worth 3 per cent., we arrive at the following results :—

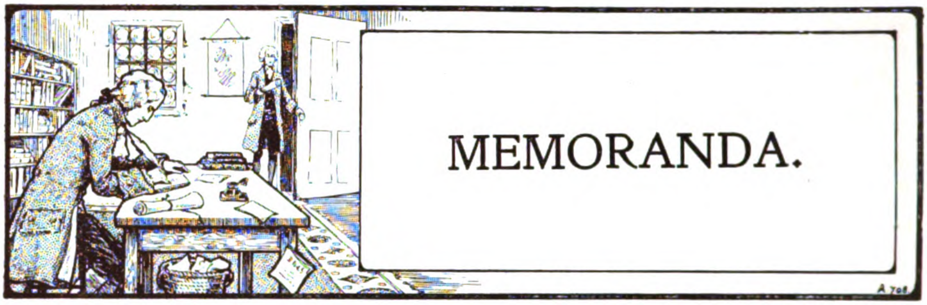
		TIMBER.	CONCRETE.
	First Cost ...	£100 0 0 ...	£150 0 0
	Life ...	12 years ...	24 years
1	Interest	£3 0 0 ...	£4 10 0
	Sinking Fund ...	7 0 0 ...	4 7 0
		10 0 0	8 17 0
2	Interest	£3 0 0 ...	£4 10 0
	First Cost divided by life ...	8 6 8 ...	6 5 0
		11 6 8	10 15 0
3	First Cost with compound Interest for 24 years ...	£203 0 0 ...	£304 10 0
	One renewal in 12 years, with compound interest ...	143 0 0 ...	
		346 0 0	304 10 0

It will be seen that the difference is in every case in favour of the concrete sleeper. As Mr. Raymond correctly remarks, precision in such comparisons is impossible because, although the formulæ may be quite correct with their several assumed bases, the data are of necessity but estimates. On the other hand, there is always an indeterminate element, which cannot be expressed in figures, in the inconvenience, delay and risks involved in relaying a road with new sleepers.

Owing to the destruction of forests, railway sleepers are bound to increase in cost, and it is time English engineers began to try reinforced concrete sleepers at least on branch lines where trains travel at lower speeds than on the main lines, and a perhaps somewhat less elastic road than a timbered road is of not much consequence. In order to give the track on concrete a certain amount of elasticity, some kind of cushioning could be adopted under the cast-iron chairs, which will enhance somewhat the cost of concrete sleepers, but not sufficiently perhaps to turn the scale against them.

The above estimates are given tentatively, as every permanent way engineer may have his own views on the subject, and will prepare his comparative estimates in accordance with them.

Another fact favouring the use of concrete sleepers is that, even if they do not last for ever, they will form an excellent building material after they have served their time in the railway track.



MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Tests of Cast-Iron and Reinforced Concrete Culvert Pipe.[*]—The growing use of concrete and reinforced concrete pipes for culverts in railway embankments has made it desirable to investigate the nature and distribution of the loads borne by such pipes, and extensive experiments have been made with this object, under the direction of Prof. Talbot, of Illinois, the results of which are contained in the Bulletin of April of this year. The stresses in loaded pipes were investigated mathematically, regarding the pipes first as thin, and then following Bach's method for curved beams, introducing the necessary correction for thickness. The results are of considerable interest to engineers, but naturally apply only to certain definite conditions of loading. When the earth round the pipe is badly tamped, the lateral support becomes small, and the pipe really rests on a strip along the bottom. The load is then concentrated, and the conditions are really the same as when a section of the pipe is being compressed in the ordinary way in a testing machine. Tests were therefore made on rings cut from each kind of pipe, both with concentrated load (top and bottom) and with distributed load (section embedded in well-rammed sand enclosed in a box). It is not safe to assume uniform lateral support, and when the filling is sufficiently good to contribute notably to the strength, this must be considered merely as an additional margin of safety.

Cast-iron rings under concentrated loading broke at a calculated stress one quarter less than that to be expected from the results of tensile tests on rectangular specimens cut from the same pipes. On the other hand, plain and reinforced concrete pipes broke under loads correspondingly well with the calculated strength.

The reinforcement employed was both in the form of corrugated bar hoops and in that of netting, some longitudinal reinforcement being generally also present. Failure takes place initially either by tension failure in the steel or by shearing in the concrete. Stirrups are of value. The bell lessens the strength of the pipe.

The results will be appreciated by all who have occasion to construct culverts, as the advantages of reinforced concrete over cast-iron are made clearly manifest.

Reinforced Concrete Construction for Colliery Work.—The Londonderry Collieries, Limited, have recently adopted reinforced concrete on the Kahn system for the heapstead and screening house floors at their new colliery at Dawdon, Seaham Harbour, the total area covered being about 2,500 sq. yds. The main girders consist of rolled steel joists of 35 ft. span, spaced 11 ft. to 14 ft. between centres. Between these the secondary beams, 16 in. by 8 in., are placed at about 6 ft. centres, and over these is a 4 in. thick floor. The floor, designed for a safe live load of 184 lb. per sq. ft., is made up of a combination of beams and slabs, and is claimed to be at least 40 lb. per sq. ft. lighter than any other method of construction. The work at Dawdon has been carried out by the Trussed Concrete Steel Company, Ltd., of Caxton House, S.W., under the supervision of Mr. Robert Curry, of the Londonderry Collieries, Ltd.

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[*] By Arthur N. Talbot (University of Illinois Engineering Experiment Station, Bulletin No. 22, April, 1908).

Reinforced Concrete Railway Sleepers in Austria.—We note with interest the following semi-official communication in some of the Austrian technical papers regarding reinforced concrete railway sleepers:—

> "The Austrian Government Railway Department has now decided to seriously consider the question of replacing its hardwood railway sleepers by reinforced concrete railway sleepers."

A similar decision has been arrived at by the Hungarian Government Railway Department. It has been shown in local experiments of the last seven years that reinforced concrete railway sleepers are reliable both for heavy work and for curves, and that the life of a reinforced concrete sleeper may be taken as from four to five times that of a hardwood sleeper.

It would appear from estimates made that the great cost of maintenance in the case of wooden sleepers, which reaches from 6d. to 6·5d. annually in Austria, would be reduced, by the adoption of reinforced concrete, to 2d. or 2·5d. per annum.

Highway for Automobiles.—On the Long Island automobile cement highway several bridges have had to be constructed. These bridges, where the cars pass over them, form the only ascents to be encountered on this first 11-mile stretch of the new highway. The road is gradually raised where it approaches a cross-highway. The bridges have abutments sufficiently high to enable a railway train or a large cart to pass under. Heavy steel girders, similar to those used for the roof of the New York Subway, connect the tops of the abutments, and around the girders runs a wooden mould filled with cement and crushed stone until the desired level is obtained, making the bridges at all intersecting roads practically solid cement, steel, and stone. The road is described by an automobile driver as absolutely dustless. It has a grand stand extending for three miles.

Swansea's New Dock Works.—The members of the Swansea Harbour Trust have made another of their periodical inspections of the dock works in course of construction, and were favourably impressed by the progress made by the contractors, Messrs. Topham, Jones & Railton. It is expected that the new fish wharf will be completed by the end of the present year, and that the new dock, which between its extreme points is nearly a mile long, and will have a water area of 67½ acres and a quayage extending over 13,500 ft., will be ready for opening next summer.

Competition for the Design of a Reinforced Concrete Building.—The proprietors of the *Builder* have offered a prize of twenty guineas and a second prize of ten guineas for the best designs for the architectural treatment of a corner building in reinforced concrete, which is supposed to be a club having a frontage of 120 ft. to a height of 74 ft.

What is especially to be aimed: to express the character of a homogeneous and jointless structure, as distinct from the character properly belonging to a masonry building.

We congratulate our contemporary on arranging this very useful competition, and it will be interesting to see the result.

The assessors will be Mr. Reginald Blomfield, A.R.A., Mr. Walter Cave, F.R.I.B.A., and Mr. H. H. Statham, F.R.I.B.A.

The only exception we would like to take in respect to this competition is that the description "Ferro-concrete" should be used throughout instead of the official description of the material, which has been indicated by the Royal Institute of British Architects, public bodies, and other Commissions, to be Reinforced Concrete.

London Building Act and Reinforced Concrete.—The Building Act Committee recommend that application be made to Parliament in the Session of 1909 with a view to the amendment of the London Building Act, 1894, so as to facilitate the use of steel or reinforced concrete in the construction of buildings and to make any necessary provision with regard thereto.

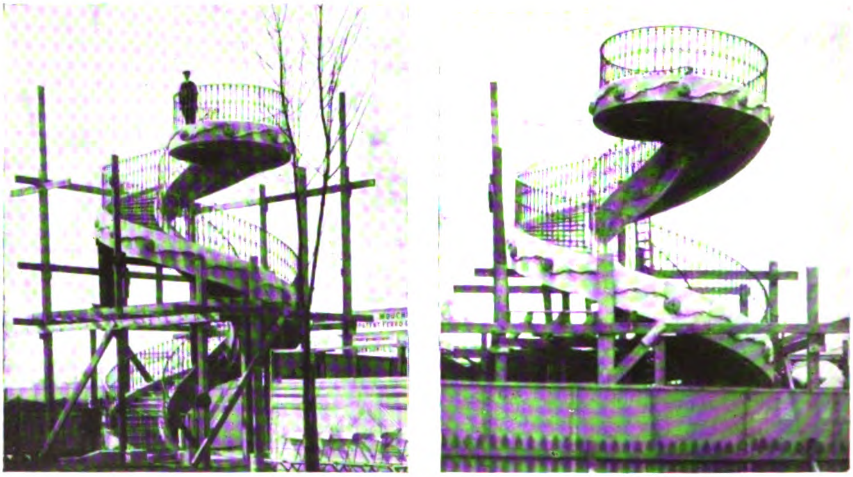
Concrete Telegraph Poles.—Concrete telegraph poles are to be experimented with by the Pennsylvania Railroad during the coming winter. The initial experiments will be conducted on a stretch of track between Pittsburg and Chicago. It is believed they will be better and resist storms and will be longer-lived than wooden poles.

Concrete Bridge in Italy.—A newly-erected bridge constructed of reinforced concrete, spanning the river Magra at Costigliole, on the new road from Caprigliola to Spezzia, is now open to traffic. The bridge is 984 ft. long, 24 ft. wide, and it stands about 33 ft. in the clear above the normal water level. It consists of five spans, or arches, each with a chord of 166 ft., and the deck is supported by 400 pillars of reinforced concrete.

Concrete Mantelpieces.—A Boston architect suggests that cement mantelpieces would form a useful substitute for the wood commonly used. He considers the advantages obvious, as there would be no inner facings of tile or marble needed, no joints to crack or open with heat, no material to burn. As cement in its natural colour is not very artistic, the material could be coloured light red, or cream-coloured like Caen stone.

LECTURES.

Institution of Mining and Metallurgy.—An interesting paper by Mr. S. J. Truscott, *Member* of the above named institution, and Mr. John P. Fuller, *Associate*, was read at a meeting in the rooms of the Geological Society during last month, the subject being Reinforced Concrete Foundations for Stamp Batteries. The lecture dealt with the replacing of wooden mortar blocks for the stamp battery at Redjang, Lebong, Sumatra, and was illustrated by line drawings. Some interesting details were given of the proportions used.



Reinforced Concrete Spiral Stairway at the Franco-British Exhibition.

City and Guilds' Technical College.—We observe with very great pleasure that this college has on its curriculum for the coming winter, a lecture by Mr. Chas. F. Marsh, M.Inst.C.E., on reinforced concrete. It is a step in the right direction that an institute of this kind should find time for matters relating to reinforced concrete.

EXHIBITIONS.

Reinforced Concrete at the Franco-British Exhibition.—On pages 281-2 of our previous issue we published a description and drawing of a reinforced concrete stairway at this Exhibition, and we now present two views of this interesting exhibit, which was constructed on the Hennebique System, and erected by the Yorkshire Hennebique Contracting Co., Ltd., to the designs of Messrs. L. G. Mouchel & Partner, Ltd.

In addition to the examples of reinforced concrete work mentioned by us in our last issue, we find that reinforced concrete floors, laid by the Armoured Tubular Flooring Co., of Westminster, on their well-known system, have been utilised in the Soap Milling Hall, Picture Gallery, Restaurant and Tower of the Irish Village.

The first-mentioned building, known as the Soap Milling Hall, is of special interest for architects, engineers, etc., by reason of its simple adaptation for fixing shafting and providing openings for belt pulleys, etc., and in addition, as in the kitchen portion of the restaurant, the risk of fire is reduced to a minimum. A further example is to be found in the Picture Gallery, where the Armoured Tubular Flooring has been used as a roof, where it combines lightness with strength and durability.

Mr. Edmond Coignet, of 20 rue de Londres, Paris, and of Edmond Coignet Ltd., 20 Victoria Street, S.W., has been awarded the *Grand Prix,* Class 28, French Section, Machinery Hall, at the Franco-British Exhibition, for his exhibit in connection with the Coignet system of armoured concrete.

The Associated Portland Cement Manufacturers (1900) Ltd. — This firm had a large exhibit at the Building Trades Exhibition, at Birmingham, where they erected a stand of considerable architectural pretensions for the display of their products. In addition they showed a working equipment for modern cement testing. The stand was quite a feature of the Exhibition.

The British Concrete Co., Ltd., of Castle Street, Liverpool, had a very interesting exhibit at the Ideal Home Exhibition, at Olympia, where they demonstrated the process of rapidly making concrete blocks.

CONTRACTS.

The British Concrete Steel Co., of Newcastle-on-Tyne, inform us that the following are among the recent contracts secured by them. A retaining wall at Newcastle-on-Tyne 32 ft. high; a reservoir near Durham of 175,000 gallons capacity; two new bridges of 48 and 42 ft. span respectively; the widening of two bridges in Northumberland; the partial rebuilding of a bridge over the river Tyne, the spans to be rebuilt being 60 ft. and 36 ft. respectively; and floors for buildings at Dulwich, Perth and Chesterfield.

The Columbian Fireproofing Company, Ltd., of London, have secured contracts for floors in the Mitchell Library and the Royal Infirmary, Glasgow; the Great Ormond Street Hospital, London; the Cavalry Club, Piccadilly; a Motor Club, Coventry Street; flats, shops and offices in various parts of the Metropolis; schools at Acton, Norwich and Islington; halls at Plaistow and Canning Town; in several London County and Midland Banks; and also in the Chingford Reservoirs for the Metropolitan Water Board. Messrs. C. Wall, Ltd., are acting as contractors on the last-named job.

Cubitt Concrete Construction Co., of London, state that among the work recently undertaken by them are the machine foundations for Messrs. Callard, Stewart & Watts, of Kensington; all the reinforced concrete work at "Westacre," Harrow-on-the-Hill; the Chelsea stores for Messrs. Whitbread & Co., and slabs for the repair of Ryde Pier.

Johnson, Clapham & Morris, Ltd., of Manchester, have secured a contract for concrete lattice with His Majesty's Government Prisons Department. 5,000 sq. yds. of this concrete lattice will be used at the Maidstone and Borstal prisons.

Patent Indented Steel Bar Co., Ltd., have given us the names of the following structures in which Indented Bars will be used as reinforcement:—Post office in Glasgow for H.M. Office of Works; platform for the Admiralty extensions at Devonport and Peterhead; new schools at Ramsgate for the Kent Education Committee; a fire station, a sailors' home and a grammar school at Southampton; three reservoirs in Ireland, Waltham Abbey and Bath respectively; a church at Walworth; the Caledonian Railway extensions near Glasgow; the staircases and floors for the Selfridge Stores, London; a water tower at Birmingham and one at Immingham; a sub-station for the Charing Cross Electric Light Co.; a floor at Charing Cross Station for the S.E. & C. Railway Co.; several cotton mills in Lancashire (over 500 tons in all), and a number of other instances in all parts of the country.

Rib Metal Co. of London.—We understand that the Rib Bar reinforcement used by this firm has been utilised on the Motherwell Reservoir, N.B., a football stand at Tottenham, and a grand stand for the York Race Committee. It is an American invention.

Simplex Concrete Piles, Ltd.—Messrs. J. & W. Stewart, the licensees for these piles in Great Britain, have secured the contract for the foundations for the new City Hall at Perth, for which reinforced concrete will be adopted; also for pile foundations for a water tower at Wood Eaton, Staffordshire. The Simplex system of concrete piling has also been adopted for a pier extension at Aghia-Marina, Greece, for the Helleniques Railway, La Société de Constructions des Batignolles being the contractors for the work. Another Continental example is the foundations for the Railway Administration Buildings in Munich, Messrs. J. Kleine acting as contractors.

D. G. Somerville & Co.—Among the contracts secured by this firm during the last three months are:—A large telephone exchange at Deptford; bridge for the East Ashford Urban District Council; large foundation raft for boiler and engine-house, London; factory for "Kodak, Ltd.," Harrow, on the Kahn system; motor house, London; coal bunker, Lancashire; sewage tanks, Kent; rotary kiln house, Harefield, Middlesex; residence, West Cowes.

Stuart's Granolithic Co., Ltd., of London, inform us that the following are some of the contracts recently obtained by them. General Post Office, Edinburgh; Clifton Asylums, Yorkshire; additions to the Northern Assurance Co.'s building, Liverpool; mills and bakeries at Bermondsey and Walsall; grain silos (10,500 tons) and granaries at Hull; paper mills at Bury and Carron Grove; schools at High Wycombe; Monzie Castle, Perthshire, and a mansion at Morvern, Argyleshire; a new retort house in Liverpool, and various industrial buildings in different parts of the country.

Vulcanite, Limited, inform us they have secured a contract for covering some large concrete buildings at Kingstown, Jamaica, where. since the earthquake, they have covered many roofs with great success. They have further just completed two large contracts in England, one being some 15,000 yds. super. Vulcanite Roofing at Messrs. Humber's new works, Coventry, the other some 20,000 yds. super. at the Wall Paper Manufacturers, Ltd., Greenhithe.

We are requested to state that the offices of this firm have been moved from Parr's Bank Buildings, Manchester, to 41 Corporation Street, Manchester.

CATALOGUES.

The Armoured Tubular Flooring Co., Ltd., of Westminster, have issued a useful circular giving particulars of their system of floor construction. We have on various occasions commented favourably on this floor system, which has the advantage of lightness combined with a very high fire resistance.

In the pamphlet now issued work is shown in course of execution at the Albert Foundry, Belfast; on a factory in Camden Town; at a motor garage in Brighton, and at some London motor works, in each of which cases the flooring system appears to have been very practically applied.

Useful data are given, and there is an absence of that form of secrecy in the pamphlet as to the system and the methods of calculation which we have condemned in respect of some other pamphlets which have been put before us.

This firm have also called our attention to the Press which has been for some time in use on the Continent for the manufacture of the coke breeze concrete tubes used in the construction of their flooring. These tubes are similar in design to the hollow blocks used in wall construction, but as they are not relied on for strength in the floor, but only for the purpose of filling members, they are made of the lightest possible fireproof material.

The English Company, who hold the sole rights of the patent system of Armoured Tubular Flooring for the United Kingdom, have adopted these presses in a revised form—they use two classes of tube presses, which are made in Liverpool, known as the Quadruple and Single Press.

The Quadruple Press forms part of the stationary plant at the Company's various works, and is capable of producing four tubes in one operation by a mechanism that is worked by hand. The Single Presses are lighter, and can be transported to any site.

The coke breeze and cement forming the component parts of these tubes, which vary in size from 5 in. to 12 in., but of a uniform length of 9 in., are so compressed that they are easily handled before being placed on the drying racks.

Crosby Lockwood & Son have sent us the first number of a Quarterly Circular of Engineering and Technical Literature (classified under subjects), published at their recently-opened Technical Book Room in Victoria Street. The Circular contains all the most important works in Engineering, Science and Technology published during the past three months in England and in America, and as it will be repeated every quarter should certainly prove of the greatest assistance in the offices of English engineers.

Johnson, Clapham & Morris, Ltd., of Manchester, have sent us an interesting catalogue, entitled "Monolithic Brickwork and the Clothing of Steel Framed and Reinforced Concrete Buildings."

The booklet contains descriptions of a number of tests with the wire mesh reinforcement which is the speciality of this firm, and is also exceedingly well illustrated with photographs of internal and external work which has been carried out.

Patent Indented Steel Bar Co., Ltd.—We have just received the fourth number of the "Bulletin" issued by this firm, which contains some interesting illustrations of work carried out with "Indented" bars. The buildings described are of a very varied description, and include the new Selfridge Stores.

Messrs. D. G. Somerville & Co., of London, have issued a comprehensive pamphlet indicating recent work executed by them. The feature of this pamphlet is Reinforced Concrete Construction and its standard specification for reinforced concrete, both of which series of memoranda should be useful, not only to Messrs. Somerville's clients, but to all users of concrete and reinforced concrete, and for this alone the pamphlet will merit retaining for reference purposes.

Most of the works dealt with in the pamphlet have already been mentioned in our columns, but, if we should single out any specific illustrations, there are those of the various telephone exchanges upon which the firm has done work, and upon which we publish a further description under New Works, and the excellent arched roofs at St. Charles' College Chapel, Notting Hill, which claim special attention.

Messrs. Somerville also give in the pamphlet in question a considerable amount of data for designers of steel frame work, in respect to which there are also some useful introductory notes on constructional steel work generally.

The Trussed Concrete Steel Co., Ltd.—We have received an exceedingly well-printed catalogue of some 120 pages of the Trussed Concrete Steel Company, Ltd., in which, besides illustrating a number of works to which their system has been applied, a considerable amount of useful information is presented in a thoroughly technical manner.

The illustrations of works executed are very much to the point as illustrating the various forms of construction to which the system in question can be applied.

We hold that among the examples presented, the roof of the Hammersmith Baths, the bridge of the York Racecourse, some of the retaining walls shown, and the culvert to the North-Eastern Railway particularly claim attention.

Regarding technical data in the catalogue, there are, of course, different aspects of looking upon the calculus presented, but there can be no doubt that the specification for reinforced concrete included in the pages is most useful.

We think that for a firm whose primary field of occupation is intended to be in the confines of Great Britain, references to work in the United States are by no means an advantage, and sometimes, even, prejudice possible users, and it is thus to be hoped that the next edition of this excellent catalogue will be free from reference to the United States.

A curious error that has crept into the pamphlet is the description of that eminent architect, Mr. Norman Shaw, as the Past President of the R.I.B.A. Mr. Shaw is one of the architects who, probably like quite a number of others, prides himself on not being connected with any architectural society.

In conclusion, we can only say that the catalogue is well worth keeping for reference purposes. It is one of the best we have seen.

EDITORIAL MEMOS.

CONTRIBUTIONS.—Original contributions and illustrations are specially invited from engineers, architects, surveyors, chemists, and others engaged in practical or research work. MSS. should be written on one side of the paper only, giving full name and address of the author.

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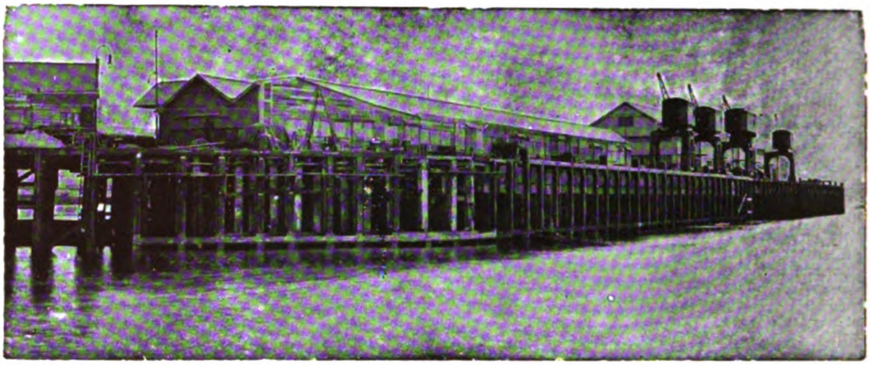

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CONCRETE AND CONSTRUCTIONAL ENGINEERING

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EDITORIAL NOTES.

THE CONCRETE INSTITUTE.

THE work of the Concrete Institute bids fair to be of such importance that we deem it advisable to accord considerable space to its meetings in these columns. It will be observed that we have adopted a form for reporting the papers and discussions of the Institute that will make reference to any particular question as easy as possible. It is also our intention to index the subject-matter of the papers and discussions annually.

Regarding the progress made in the organisation of the Institute itself, we deal with some points elsewhere, and it may be anticipated that the year 1909 will see a considerable development in its sphere of influence.

THE RECISION OF BRITISH PATENTS HELD BY FOREIGNERS.

ALL interested in the cement industry will have been pleased to observe the recision of a British patent, which protected in Great Britain certain asbestos and cement slabs made in Belgium and freely imported into this country in competition with British-made slabs.

It is, of course, regrettable that a foreign article made entirely abroad should find a ready market in this country, when slabs, not very dissimilar, have long been made in this country, of equal if not better quality, and at a price but fractionally higher.

But the craze for cheapness and an entirely misguided sense of so-called " economy " is inducing the officers of our public departments and professional men in private practice alike to put almost anything not flagrantly imperfect into buildings of all kinds, regardless very frequently as to what used to be considered to be of " first-class " quality, and regardless entirely of the source of origin as long as some trivial saving in the capital outlay can be effected. Patriotism seems to be a thing of the past with certain building owners and their professional advisers alike. Thus British contractors are frequently, in these times of keen competition—much against their will though—driven to order goods from abroad, which they know are so often worse than the home products, and the importation of which they can observe with their own eyes to be materially affecting some of our staple industries and swelling the ranks of our unemployed.

THE ADVANTAGES OF THE NEW PATENT ACT.

IN a journal of this description politics are *taboo*, and the pros and cons of the political aspect of free imports can find no place, but what this journal does hold is that the lethargy and indolence of many of our public officers and our professional men alike in the matter of letting home industries collapse, rather than make some effort to encourage them, must be promptly stopped. By the placing of orders at home when the reliability of a product obtained will probably be of a higher standard than the foreign one, they are acting in the interest of the building owner even if a slightly higher capital outlay is incurred. The fractional extra capital expenditure will be amply repaid by the lesser annual cost in maintenance and repairs and the longer life of the structure, not to speak of the indirect benefits accruing to all building owners in times of fair industrial prosperity. The present unsatisfactory state of business among the purveyors to the building trade is due to no small extent to the misguided *laissez faire* that seems almost to encourage the foreigner to dump his surplus building materials into the United Kingdom.

If the Patent Act will at least do something to take away the right of the foreigner to bar Britishers from making such special building products that can be made equally well, if not better, in this country, with British material and British labour, we are indeed to be congratulated on having some slight safeguard against the undue importation of what may be termed specialist building products.

A DANGER IN THE NEW PATENT ACT.

On the other hand, it should be borne in mind that the new Patent Act will cause better class foreign firms having a large stake in British patents to settle among us and to manufacture products in factories alongside our own. These factories will, no doubt, give employment to a large number of British workmen, but it may be safely assumed that the administrative posts will be occupied by foreigners, and the profits earned will be transferred to the countries from which these firms hail—*i.e.*, the pecuniary advantage to the nation will not be quite as great as the public Press would wish us to believe. Further, the foreign firm that establishes works here will have modern plant and introduce the latest methods, for the foreigner is very " up to date " in such matters, and also generally enjoys the advantage of a sound technical education, a very great pride in his work, and a certain plodding assiduity which makes him a competitor claiming respect. Thus our own administrative chiefs of the industries concerned will have to be very alert and energetic in order to avoid finding that some of the profits they have been in the habit of earning are not diverted to the foreign firms who are now to work alongside them owing to the Patent Act we refer to. Further, a foreigner once established here on account of the Patent Act will not necessarily limit his work to the patented products he wishes to protect, but is likely to soon become a well-managed and modernly equipped competitor in products other than those for which he commences operations in our islands.

THE LONDON BUILDING ACT AND REINFORCED CONCRETE.

The London County Council have given notice that they propose to amend the London Building Act in a manner that will have special bearing on steel frame buildings and upon reinforced-concrete work.

Dealing with the proposed clauses on reinforced concrete, we understand that the intention is to embody a clause in the London County Council General

Powers Bill which will give the Council power to frame regulations governing reinforced concrete, that these regulations are to be administered by the district surveyors, and that any dispute between the district surveyor and those responsible for the work is to be referred to the London County Council, the decision of which body shall be final.

Summarised, this means that, on the one hand, the County Council propose to give the building owner the long desired freedom of being able to erect external walls in reinforced concrete, subject to certain regulations, but, on the other hand, the existing freedom of regulation as to reinforced concrete inside a building is to be cancelled, and regulations are to be framed by the Council to govern the use of reinforced concrete in positions where at present there is no restriction beyond the ordinary control of the district surveyor, who uses his discretion as to the stability of work executed within the containing walls of a building.

We should, in the first place, premise that permission to erect walls in reinforced concrete is essential in our view for the development of modern building construction. We, however, realise that if such walls are to be erected in reinforced concrete they must be subject to regulations. We also agree that, whilst it would generally be of advantage if such regulations were immediately to form a part of the Act of Parliament, this is impracticable at the moment, as the scientific *data* upon which such enactments should be based are not yet as complete as one would desire.

On the other hand, such regulations should not be framed solely at the discretion of the Council and administered by district surveyors, with any points in dispute arising thereunder again to be decided solely by the Council.

We think the regulations should not be framed unless professional bodies concerned have had a voice in the matter; and, secondly, that disputes should finally come to the Tribunal of Appeal for decision. We should also prefer to see by-laws enacted in the place of regulations, as there is a recognised method for obtaining such by-laws, and we do not think the difficulties of settling by-laws should be insuperable.

As to the withdrawal of the present liberty of using reinforced concrete within the four walls of a building, on a technical as distinct from political question, we fully realise that a public authority such as the Council must be desirous of eventually defining the character of all construction within the building, as is the case in many Continental capitals, but we hold that such enactments should be postponed until they are applied to *all* forms of construction within the building, be they timber, steel, plain concrete, or reinforced concrete.

At the very most we would at the moment regulate the use of reinforced concrete within the building by enacting some general safeguard in the proposed Act of Parliament from the all-important fire point of view.

We think the maximum size of the aggregate, the minimum thickness of concrete around the metal reinforcement, and also the necessity of using Portland cement only of the British standard quality, should be embodied as subclauses in the Act, just as there are sub-clauses of a fire-protective character in the section devoted to steel frame construction.

In other words, we think that whilst liberty is justifiable within the four walls until it is limited for all forms of material, the same restrictions as to the protection of steel frame construction proposed by the promoters, or similar ones, had better be immediately laid down in the Act for such metal as there is in reinforced concrete.

The reinforced concrete we have seen in some buildings in the Metropolis with only about ½ in. of protection to the steel rods must eventually lead to reinforced concrete meeting with a setback as a fire resistant, for structures of this character must inevitably fail in anything like a serious fire.

Summarised again, we should thus prefer for the moment to see powers only accorded to the County Council to make regulations for external walls. We do not wish to see reinforced concrete restricted within the building beyond the necessary fire-protective clauses until all materials used within the building are subject to regulation.

THE LONDON BUILDING ACT AND STEEL FRAME CONSTRUCTION.

THE proposed rules as to steel frame construction, which are to form part of the Act—*i.e.*, sub-clauses fixed by Act of Parliament—are, generally speaking, of a practical character, and we also observe that due care has been taken to make provision for the protection of the steel framing from the effects of corrosion and from fire. Regarding protection from fire, we would, however, specially warn those concerned that good concrete appears to be the only material existant that is a generally practicable protective—that it is at the same time a perfect protective against corrosion as also against fire. But this concrete should be of the best character ; thus its lowest quality should be set out by Act of Parliament, as also the maximum size of the aggregate used.

We trust on a future occasion to deal more fully with the proposed enactments as far as they relate to steel frame construction.

THE LONDON BUILDING ACT AND THE TECHNICAL SOCIETIES.

THE Parliamentary Committee of the London County Council very wisely put the Bill—so far as it related to the Building Act matters—before the various technical societies concerned in the subject, and although circumstances have prevented those societies having the necessary time to fully consider the questions involved, it was certainly a step in the right direction to put the proposed enactments before them for observation.

Among the societies who received the Bill for consideration were :—the Royal Institute of British Architects, the Institution of Civil Engineers, the District Surveyors' Association, the British Fire Prevention Committee, and the Concrete Institute, and there has been quite a flutter of excitement on the proposals, for, as was to be anticipated, there is a most extraordinary divergence of opinion. The Superintending Architect to the London County Council has also very courteously attended certain of the meetings, such as those of the Royal Institute of British Architects and the Concrete Institute, and has unofficially explained his personal views on the proposed enactments, a step both politic and useful, for it led to clearer understanding of the Bill.

In short, the Institution of Civil Engineers appears to concur in the main with what is proposed. The Royal Institute of British Architects object in principal to the embodiment of the rules controlling the steel framework as part of the Act, and disagrees in other points of importance. The Institute would prefer regulations drafted from time to time by the Council. The District Surveyors' Association concurs in the main. The Fire Prevention Committee desires some additional safeguards from the fire point of view, particularly in respect to reinforced concrete. Lastly, the Concrete Institute welcomes the proposed additional facilities for building walls in reinforced concrete, but objects to the idea of new regulations to control the interior construction and the absence of an independent authority for appeal, such as a Tribunal Appeal.

It will certainly require considerable tact in the piloting of the Bill to arrive at some compromise that is equitable, and at the same time agreeable to the majority of those concerned.

THE LONDON COUNTY COUNCIL AND THE LONDON BUILDING ACT.

REGARDING the County Council's own attitude—if ever it requires an instance to indicate the absurdity of technical legislative matters being discussed in a large lay assembly, the Spring Gardens meeting of December 15th affords it. Two " Progressive " members—Mr. Geo. Dew and Mr. Phillimore—quite rightly suggested that the proposed clauses regarding reinforced concrete had better specifically indicate that the actual materials used in reinforced concrete should be subject to regulation. Their proposals were to the point, and the additional words they suggested would have been an advantage, but apparently—owing for mere party purposes—their suggestions were thrown out by the " Moderate " majority.

Two other " Progressive " members, however, entirely departed from the technical aspects of the Bill in order to air political views, and if the " Moderate " majority here also threw out the suggestions made, they can—all questions of politics apart—only have the approval of the technical professions, for the suggestions made attacked the veriest basis of good building practice as established in the Metropolis. The Hon. Captain Hemphill—who was at one time Chairman of the Building Act Committee—and Sir John Benn, M.P., were the two " Progressive " members who devoted themselves to introducing problems of fiscal policy into the debate. They suggested that the proposed sub-clauses in the steel-frame section which wisely required that the Portland cement should be to the " British Standard," and that similarly the steel should be to " British Standard," were an indirect form of fiscal protection, and disadvantageous to the foreign manufacturers who desired to import their products into London. They apparently did not realise that the foreign manufacturer not only can, but does, when he desires business in this country, produce articles that comply with our standards, and that material which does not comply with those standards is, as a rule, not of the sound and good quality generally desired by our leading technical authorities. The provisions in the Bill are not intended to protect our home industries—however desirable this might be from some people's point of view—but simply to protect the building owner and the public in their desire to have building materials which are not only sound but meet the conditions both of workmanship and climate common to our capital.

It would lead too far to go further into the debate, except, perhaps to indicate that one of the few speeches really to the point was one by Mr. Pilditch, who, being a surveyor by profession and understanding his subject, explained what should have been obvious to all—that the primary intention of the proposed Act is to create additional facilities for building, and not to hamper the work, and that the whole matter was simply one of finding equitable means agreeable to those mainly concerned for giving those facilities. Mr. Taylor, by-the-bye, rightly and emphatically pointed to the futility of a long lay discussion on such a technical subject as the proposed enactments.

Taken altogether, however, the discussion in the County Council did not add prestige to that body, for it seemed to indicate that politics, rather than the public interest, were still being accorded too much attention.

THE SPECIAL COMMISSION ON CONCRETE AGGREGATES.

We print elsewhere an interim report by the Special Commission on Concrete Aggregates, the value of which comprises mainly its schedule, which presents some clear specifications for the materials in common use for concrete aggregates.

Engineers and architects have not, as a rule, accorded that care to the specification of aggregates in concrete which is, for instance, observed in the specification of Portland cement, although, as a matter of fact, a defective aggregate will seriously affect the concrete.

It will be observed that the interim report points to the necessity of considerable research work in this question, and it is to be hoped that the necessary tests will be speedily undertaken.

THE ARCHITECTURAL TREATMENT OF REINFORCED CONCRETE.

Our contemporary, *The Builder*, in offering prizes for a design architecturally suitable for a reinforced concrete building has met with a satisfactory response from the younger members of the architectural profession, who have submitted in open competition the fifty-two designs that have been exhibited at the Architectural Association last month.

The problem set to the competitors was a design for the façade of a town club house, and the conditions prescribed the length, 120 ft., and the height to the bed-line of cornice, 75 ft., as also the centre lines of the windows and the heights of the four floors included in the façade.

These restrictions have kept the competitors within reasonable limits, and confined the competition to its primary intention—the architectural treatment of a reinforced concrete building.

In determining the appropriate artistic expression for their designs, the competitors should obviously have emphasised the character or feeling—first of a club house; and secondly, of a reinforced-concrete building. In England, at any rate, the association of ideas leads us to expect in a town club house dignity and repose, not to say, staid respectability. Happily for the competitors, the expression of these qualities is peculiarly compatible with reinforced-concrete construction, and the promoters of the competition have certainly been kind to the competitors in their selection of a subject.

The suitable artistic expression for a reinforced-concrete building requires original thought, as lack of precedent precludes the assistance of associated ideas.

Firstly, it should be remembered that reinforced concrete is a monolithic, or, as the conditions describe it—" homogeneous and jointless "—species of construction, and unity appears, therefore, to be a quality to be primarily expressed. But, just as in nature the unity of animal form enclose an articulated framework supporting and connecting the whole, so in a reinforced-concrete building, properly designed, there is an articulated skeleton underlying the monolithic enclosure, and, therefore, it seems appropriate that the lines of supporting structure should find artistic expression. Finally, the surface treatment, the skin of a reinforced-concrete building, demands consideration. Unless we are prepared to leave the concrete face to tell its own tale, it is clear that the covering skin should be one appropriate to the material, and unmistakably a covering. It is curious that the competitors generally have ignored the many satisfactory and entirely legitimate surface treatments of concrete that have been described from time to time in our pages, and have attempted to find more or less suitable skins for the concrete.

The majority of the competitors have come to grief in this endeavour, and several have covered their concrete with " Carrara " ware, imitating forms and mouldings used in masonry, thus entirely losing the character of a " homogeneous and jointless structure." Others have adopted bricks, tiles, and coloured stone inlays, with an equal loss of the appropriate expression.

THE PREMIATED DESIGNS.

As to the premiated designs, the following are our comments :—

The First Prize has been awarded to Mr. F. J. Lucas (the placard on the drawings gave the name as " E. S. Lucas," but we happen to know that Mr. Lucas's signature is more artistic than legible). Mr. Lucas's design is easily the best submitted, being markedly superior in composition and proportion to any other. The horizontal lines are particularly well placed, the ground floor forming a basement, then the first and second grouped together, and the third floor as a qua-attic, well composed with open loggia, as suggested in the conditions. The vertical lines, though subordinate to the horizontal, are well marked, and the rectangularity of beam and stancheon supporting structure is well expressed. The design is singularly free from reminiscences of masonry treatment, and even on the ground floor, where grey granite is largely used, this is evident, as it is actually embedded in the concrete, a rusticated treatment being adopted in which the concrete shows in the channels. The structural lines generally are left in the concrete, finished with a grey rendered face in Portland cement and stone dust. Dark green and light green marble are used for architraves, etc., and secured with visible bronze fastenings. Bronze is also used for caps and swags. Of course, to keep, in a town, the effect the designer evidently intends, the bronze work will require frequent cleansing, but one might reasonably expect that in a club house the up-keep would not be neglected.

The Second Prize has been awarded to Mr. J. William Hepburn, A.R.I.B.A. In composition the design is somewhat similar to the first, but is less satisfactory in its proportions. We cannot approve the small semicircular-headed openings on the ground floor. Many things are possible in reinforced concrete that are not consonant with the spirit of the material, and amongst these are semi-circular arches. If arched forms are used at all they should be of very flat curvature. The twisted marble shafts as mullions to windows are scarcely defensible, in spite of Italian precedent, either as a legitimate treatment of marble or as part of a reinforced concrete building. Mr Hepburn uses mouldings cast in sections and tied in, and faience panels as decorative framings, and a gilt mosaic frieze for his upper storey. The crowning feature of Mr. Hepburn's elevation—a cornice of great projection with big trusses—is, to our mind, the best feature of his design, eminently suitable for, and characteristic of, reinforced concrete.

Other Designs.—Space does not permit us to treat fully of other designs, but there are not a few that, in our opinion, approach closely in merit to that placed second. Some fail in expression, others in composition and proportion, many are restless, and some weird in their attempts at originality.

Amongst the designs possessing merit in one direction or another are Nos. 11, 12, 15, 16, 23, 26, 27, 31, 35, 43, and 47.

FICTITIOUS PORTLAND CEMENT AGAIN.

FOR several years past Sir Cecil Hertslet's annual Consular Report relating to Belgian trade has contained items of interest to British cement makers and users, and the report recently issued is no exception to this rule. It could be wished that other British Consuls would show the same interest in these matters as Sir Cecil Hertslet, who is almost the only one amongst all our Consular representatives to take much trouble over this branch of industry. Whilst it is true that Belgium is the country from which comes almost all the foreign product which is sold in the United Kingdom under the often very misleading description "Portland cement," yet it is not the only cement-producing country which competes with British cements in our largest foreign markets, and it would be well if those British Consuls who are responsible for furnishing information which may be of use to British manufacturers and workmen would devote some attention to the progress and development of the cement industry in their respective areas, and especially in those where the local makers engage in the export trade, and compete against British makers in foreign and colonial markets.

It is to be regretted that so long a time should elapse after the termination of each year before the Consular Report can appear. In this case the Report for 1907 does not reach the hands of the British public until late in the autumn of 1908, but Sir Cecil explains this by the difficulty experienced in obtaining authentic figures from the Belgian authorities until long after the year has closed. He calls attention to the general decline in Belgian exports, not merely to the United Kingdom, but to other countries, and cement is no exception to the rule. The imports of cement to the United Kingdom from Belgium, which rose in 1904 to 231,212 tons, and which fell in 1906 to 154,547 tons, dropped to 103,149 tons in 1907. The Report says:—

> It is clear that the export trade in Belgian cement is on the decline, and there is no prospect of any appreciable improvement taking place; indeed the outlook for the industry is the reverse of hopeful. The exports, of course, represent but a part of Belgium's trade in cement, and the home market has to be supplied as well, but in this direction, too, there is little to be done, for there seems to be little or no building going on in any part of the country. All over Belgium, and particularly in Antwerp, there are almost no new buildings, either municipal or private, about to be constructed, though in the latter town there is great demand for residences at a moderate rental, which at present are very difficult to procure.

SIR CECIL HERTSLET'S REPORT.

As on the last occasion, Sir Cecil Hertslet also makes some caustic remarks upon the methods employed by some of the Belgian makers. Once more he condemns the common practice of using labels or marks in the English language, the sole object of which, he argues, must be to convey to the ultimate purchaser the impression that the goods are of British origin, and, ergo, of the well-known British quality. This condemnation is not entirely confined to the producers of the material, which is known in the circles concerned as "Natural" cement, but applies also to the Belgian makers of genuine Portland cement. His severest censure is reserved, however, for a practice which has been adopted by vendors of the "Natural" product, and we set it out at length, because although it deals with occurrences in Belgium itself, it is all too characteristic of the methods frequently employed in the United Kingdom by those who sell the same material. It must be obvious to every one of our readers that an article which depends upon methods of this sort for a market can have nothing to recommend it but its apparent cheapness, and that persons whose ideas of business morality are illustrated in this exposure are at all times to be shunned :—

> I have, in my reports on the trade of Belgium, frequently made mention of the misleading descriptions which Belgian cement dealers make use of in describing their goods, by the appropriation of English phrases and labels printed in the English language, and it is satisfactory to be in a position to be able to record here that the remarks made, and which were perfectly justified, do not appear to have been resented in this country. On the contrary, the irregular practices of certain persons in Belgium of describing natural cement as Portland cement and Portland cement of British origin are deemed by manufacturers of artificial cement in this country to be detrimental to their own interests in the home market. As direct proof of this, I was approached late in the year 1907 by the Belgian Association of Artificial Portland Cement Manufacturers with a view to obtaining my assistance in putting a stop to the practices of certain unscrupulous persons who dispose of natural Belgian cement as British Portland cement, thus injuring not only the legitimate business of British makers but also (though more indirectly) the trade of Portland cement manufacturers in Belgium. Upon ascertaining the quantity of British-made cement exported to Belgium and upon finding that the amount of cement disposed of in this country as British Portland cement considerably exceeded the amount of such exports, it was immediately apparent that indiscriminate juggling with descriptive terms was going on, and that unsuspecting buyers in this country and abroad were purchasing inferior Belgian cement under the impression that it was British Portland cement, which, naturally, was in the highest degree detrimental to the trade of British manufacturers, the high standard of quality of British cement having for years been generally recognised.
>
> It is gratifying to find that the Belgian Portland cement manufacturers, far from taking exception to any remarks made to the detriment of the dealings of some of their fellow-countrymen, are willing to unite with manufacturers of cement in Great Britain in taking any steps which may be possible in the common interest to restrain illegitimate dealing detrimental to the cement industry in either Great Britain or Belgium.
>
> But though this attitude is satisfactory so far as it goes, it has no bearing upon the practice referred to so frequently, of the disposing of Belgian-made cement with marks which (though the makers naturally say otherwise) can have no other object than to mislead. Why, it may be asked, and the answer is not a difficult one, should Belgian manufacturers of cement describe their goods with labels and marks in English? English is not the language of this country, and if Belgian cement is superior to British there is no object in describing it in a manner which tends to prove that there is something British in connection with it. If, on the other hand (and this is undoubtedly the proper construction), British cement is superior to Belgian, it is manifestly unfair that the Belgian product should be so described as to give the appearance that it is made in Great Britain.

A WARNING REGARDING BELGIAN CEMENT.

ALTHOUGH, as indicated in the earlier part of this note, the imports of Belgian cements into the United Kingdom have greatly diminished (no doubt largely owing to the unsatisfactory results obtained from their use), it still behoves every professional man, and every user, to be on his guard against this inferior material. Whilst the Customs Returns still show some 100,000 tons of Belgian cement entering the United Kingdom, it is safe to say that nothing like that quantity finds its way into the hands of consumers under its proper description. By various methods its true origin and character are concealed. It is still foisted on to consumers as " Portland Cement," and even as " Best Portland Cement," and it cannot be too strongly urged upon every reader who cares for good work (and who does not ?) that he should insist on strict adherence to the clause in the British Standard Specification for Portland cement, which requires that the material shall be delivered in packages bearing the *manufacturer's* name. He can then see for himself whether or not the cement comes from a reputable British maker. This will often enable him to dispense with formal tests, but whilst no first-class British maker's cement need fear the ordeal, the same cannot be said of the Belgian product. Little, if any, of the Belgian " Natural " cement can comply with the Le Chatelier test for soundness, or with the boiling test, and none of them show the minimum specific gravity demanded by the British Standard Specification.

THE INSTITUTION OF CIVIL ENGINEERS AND REINFORCED CONCRETE.

WE are reliably informed that the Council of the Institution of Civil Engineers has at last been persuaded to consider the advisability of co-operating in the research work necessary for obtaining technical data as to reinforced concrete.

Whatever the Institution at this somewhat belated period may be desirous of doing, it is to be hoped that the proposed work may be done in co-operation with other bodies interested in the subject.

The "powers that be" in Great George Street missed the opportunity of doing pioneer work for reinforced concrete some five years back. Other societies have since done much that the Institution should have long taken in hand. It now behoves the Council of the Institution, if taking up the question of reinforced concrete, to avoid anything that does not lead to harmony and uniformity with what has been, and is being done so well elsewhere.

LOAN PERIODS ON REINFORCED CONCRETE.

IN our previous issue we had occasion to make some severe strictures, both regarding the policy of the Local Government Board in respect to Loan Periods on Reinforced Concrete, as also on their lack of courtesy, when the Association of Municipal Engineers desired to put forward their views by deputation.

The deputation having been refused, and a memorandum embodying the views of the Association thereupon having been put before the Board, it may be recollected that we announced that the reply from Mr. Burns' officers was to the effect that they did not see any reason for changing their policy.

Advocates for the Board tell us, in the public Press, that the policy of the Local Government Board is to protect the ratepayer from bad buildings. We also are told that every structure is dealt with separately on its individual merits.

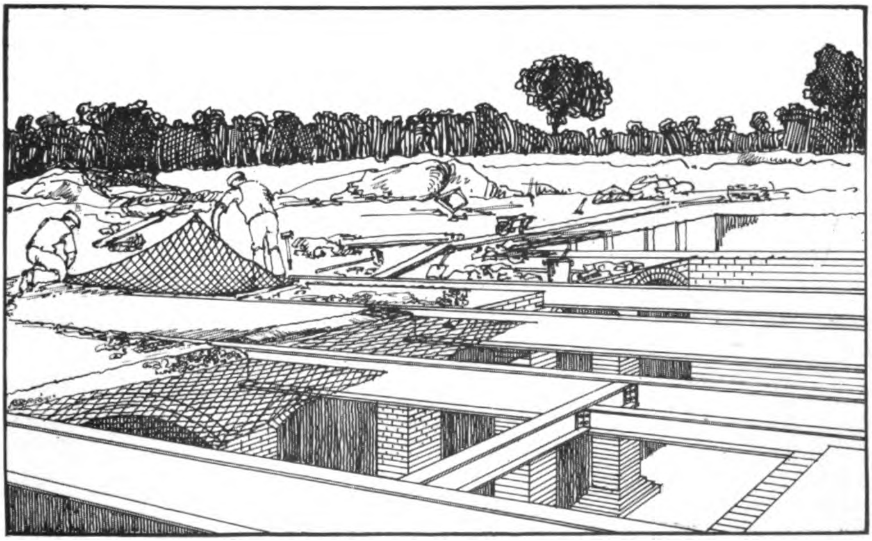
It has been our view throughout that it is necessary for the Local Government Board to protect the ratepayer, to carefully examine reinforced concrete designs, and in certain cases to test the actual work after completion, but we see no reason why reinforced concrete should be accorded an exceptional—*i.e.*, inferior—position among the different forms of building construction in use—*i.e.*, a position differing to its detriment from construction in ordinary materials.

The dislike of reinforced concrete by certain of the Local Government Board's officials has prevented local surveyors and engineers all over the country from putting forward schemes that would be eminently more practical and almost invariably more economical for the ratepayers.

Where engineers and surveyors have been sufficiently persistent to submit schemes, they have often had to abandon them for the reason that the loan period offered was too short a one. In exceptional cases, but they are quite exceptional cases, loan periods have been obtained equivalent, or almost equivalent, to those given to ordinary structures, but this has only rarely taken place. What principles governed the acceptance of these exceptional cases we know not. In one notable case the wits say that it was because the metal reinforcement was left out from the drawings; in some other instances that the words "Reinforced Concrete" were in a lettering of all too small size to attract notice. This has been notably the case with certain concrete pipes. In other words, the wits wish us to think that the Local Government Board officials did not quite realise what they were passing. Then there is the case of the Exmouth Reservoir, which has a 30-year loan period, and is often referred to by partisans of the Board as a reinforced-concrete reservoir. As a matter of fact, the piers are of blue brick, the beams are steel joists, and the concrete roof panels alone have a right to be described as being of reinforced concrete. These concrete panels are of 9 ft. span, are 6 in. thick, and have one layer of reinforcement of expanded metal. This example of a " reinforced-concrete reservoir " (*sic*)—*i.e.*, a reservoir in which there is some reinforced concrete, and upon which a full 30-years' loan period has been granted, has been so much the subject of correspondence that we think we must publish a sketch which we have in our possession, which was made by a reliable correspondent, and clearly shows what the reservoir is like.

We could deal with other curious cases. For instance, on two buildings where suitable loan periods have been granted, and that after test, the loan periods are for 26 and 28 years respectively. Both are for public baths in and near London having reinforced concrete roofs. We should like to know how these periods were arrived at.

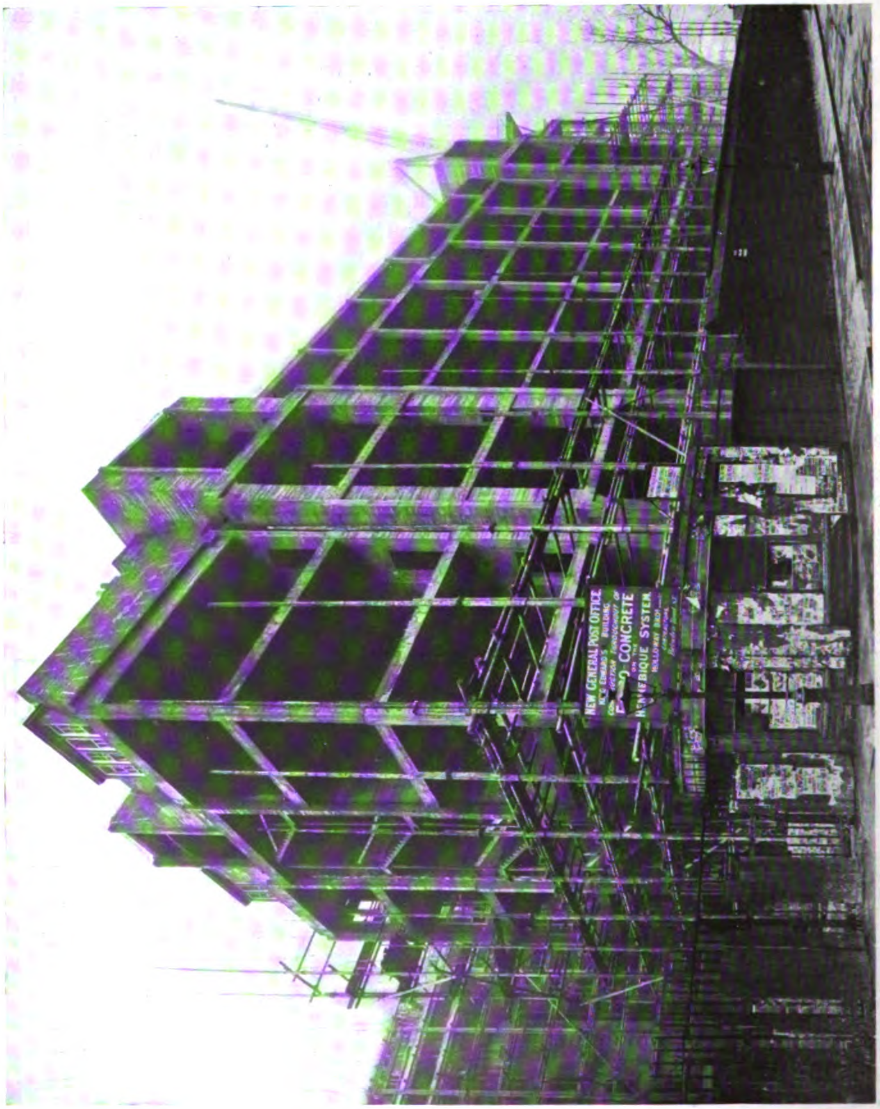
If the Local Government Board were to lay down some definite principles on which loan periods would be granted on reinforced concrete, a step would be taken in the right direction, and local surveyors and engineers would have something to go upon when submitting designs. As it is—although we grant there has been a slight improvement of late—there is nothing definite to go upon, and, taken generally, our contention holds good, that a reinforced-concrete structure—or portion of an ordinary structure built of reinforced concrete—will only get, at the moment, about half the loan period granted to structures built entirely of ordinary materials.



THE MUCH-DISCUSSED " REINFORCED-CONCRETE " (*sic*) STRUCTURE ON WHICH THE LOCAL GOVERNMENT BOARD HAS GRANTED A 30-YEARS' LOAN PERIOD.

THE EXMOUTH RESERVOIR.

The blue brick piers, steel joists and reinforced concrete roof panels



The New General Post Office Buildings.

THE NEW GENERAL POST OFFICE BUILDINGS, St. Martin's le Grand, London.

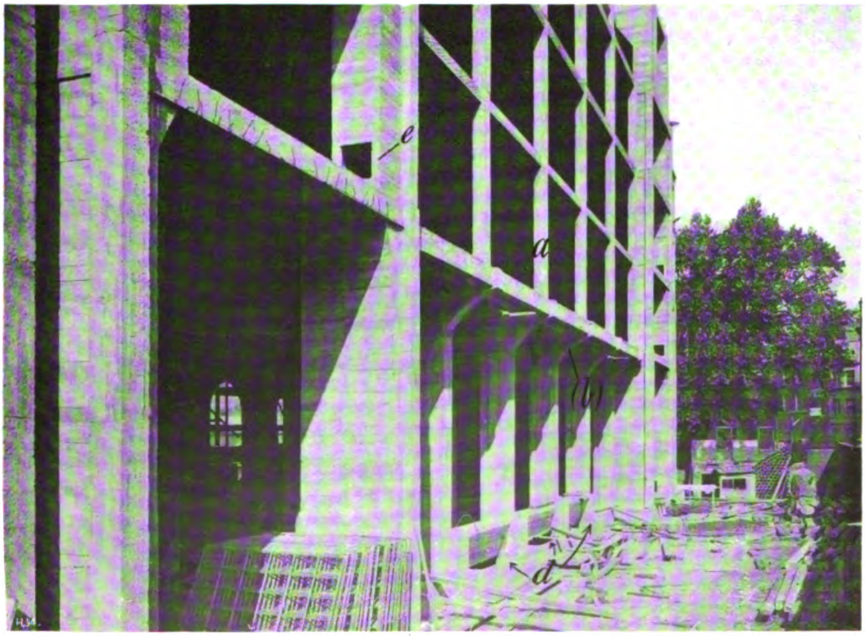
The current year will mark the structural completion of the most important reinforced-concrete building as yet erected in the United Kingdom—namely, the extensive addition to the General Post Office at St. Martin's le Grand.

We have referred to these new buildings before, when they were contemplated and when they were started, but in this issue we are able to present some excellent photographs taken during construction of the reinforced-concrete work, together with a plan which will indicate the vast extent of the structure.—ED.

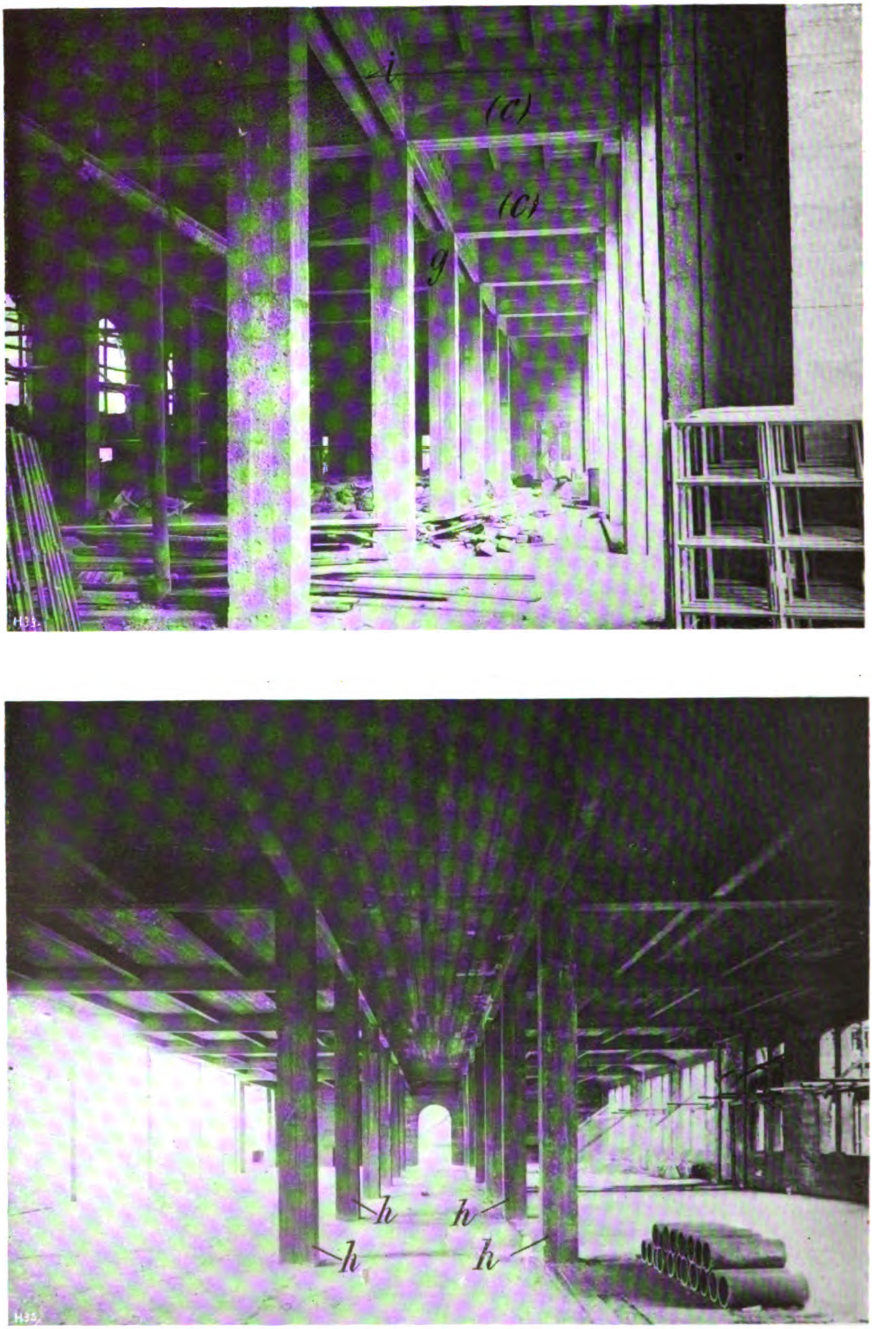
The new General Post Office buildings are almost opposite the General Post Office North, and have been designed by Sir Henry Tanner, I.S.O., F.R.I.B.A., Principal Architect, H.M. Office of Works.

For the actual constructional work the Hennebique system of "ferro concrete" has been adopted, and Messrs. L. G. Mouchel & Partners have acted as Consulting Specialist Engineers in respect to this particular work.

Messrs. Holloway Bros., Ltd., obtained the contract, and we understand that, as far as the reinforced-concrete work is concerned, the Hilton Anderson Brand of Portland Cement, manufactured by the Associated Portland Cement Manufacurers, Ltd., has been used, whilst most of the steel rods were supplied by The Whitehead Iron and Steel Co., Ltd., Tredegar, Mon.



General Post Office, Reinforced Concrete Extension. Fig. 1.



GENERAL POST OFFICE, REINFORCED CONCRETE EXTENSION. FIGS. 2 and 3.

The new building comprises two blocks, one known as the Public Office and the other as the Sorting Office, which are joined together by an intermediate building below ground level, the roof acting as the floor of the loading yard.

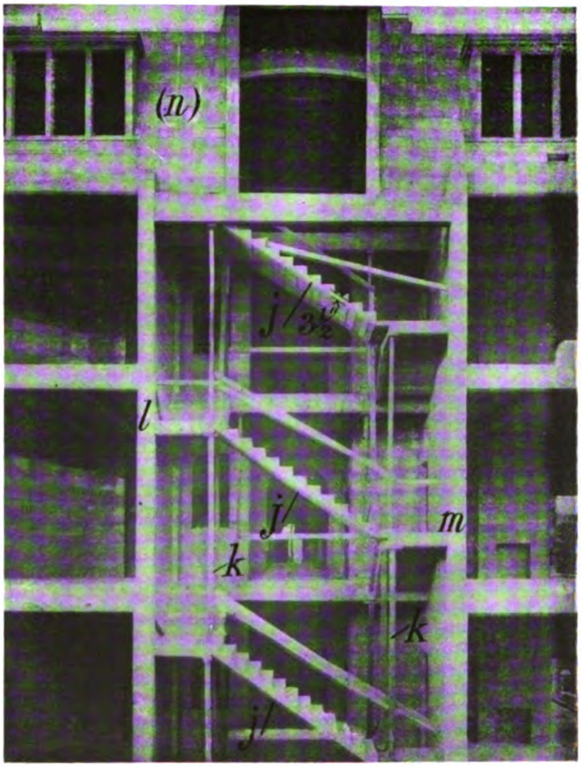
The cubic contents of the Public Office are, approximately, one and a quarter million cubic feet, while the cubic contents of the Sorting Office are about 5,780,000 cub. ft. and of the intermediate building about 900,000 cub. ft.

The main dimensions of the Public Office are 201 ft. long by 60 ft. wide to a height of 85 ft. above ground, while the total height from sub-basement level to flat roof is 109 ft. This block has six floors, of which the ground floor is 25 ft. high and the other floors have varying heights averaging 13 ft. 6 in. from floor to floor.

Regarding the Sorting Office, the main dimensions are 312 ft. by 185 ft., with a height of 63 ft. above ground, or 104 ft. from sub-basement level to flat roof, and here the floor heights are: Basement, 13 ft. 6 in.; sub-ground floor, 16 ft. 6 in.; ground floor, 20 ft. 6 in.; while the remaining floors are 18 ft., 17 ft., and 14 ft. respectively, measured from floor to floor.

The loading yard which is covered by a glazed roof, and is primarily intended for the accommodation of Post Office vans, covers an area of about 150 ft. by 50 ft., but below there is a huge basement which contains storage rooms, boiler house and various offices.

All the buildings represent in reinforced concrete the skeleton type of construction so generally adopted in the present day for steel-frame structures, but with reinforced concrete the blocks have more of a monolithic character.



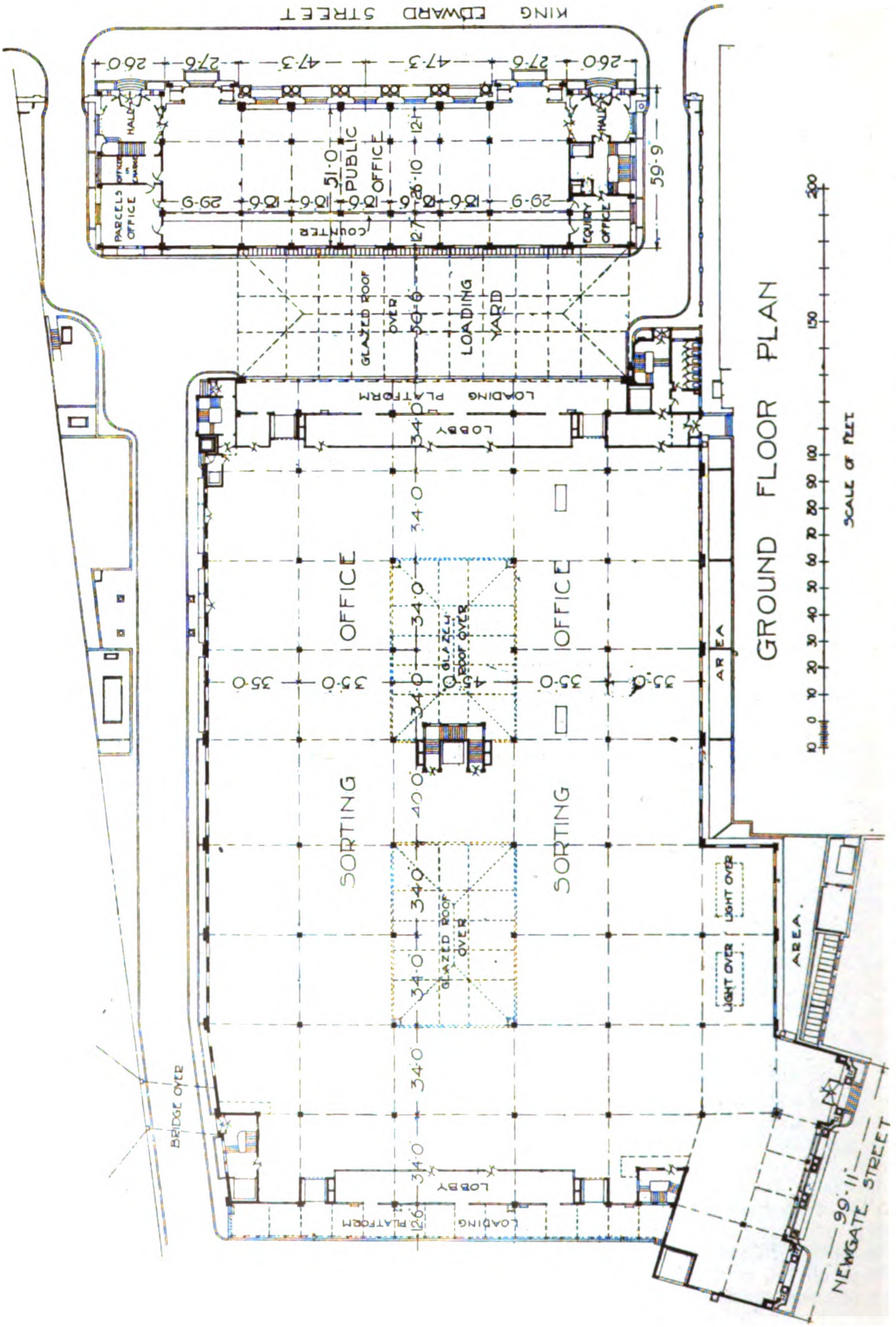
General Post Office, Reinforced Concrete Extension. Fig. 4.

DESCRIPTION.

Briefly described, each of the new Post Office buildings comprises a frame composed of reinforced concrete columns rising from foundations to roof and connected at every storey by walls and interior beams, between each storey by curtain wall panels, and at the top by beams and slabs constituting a terrace roof. All staircases, light, air, and lift wells, ventilation ducts, and, in fact, every structural detail, are built of the same material, monolithic connection being carefully maintained as in the case of the primary structural members.

As the walls have no weight to carry, their thickness is reduced to the minimum necessary for protection from excessive heat or cold and from wind, rain and snow.

One effect of employing thin curtain walls is to obviate the imposition of useless dead loads on the wall columns and beams, with the result that the dimensions and number of these members are much smaller than would be the case if massive walls had been adopted in accordance with the London Building Act. Another advantage is a vast increase of the interior space allocated to the public service.



General Plan of the Reinforced-Concrete Extension Buildings at the General Post Office, London.

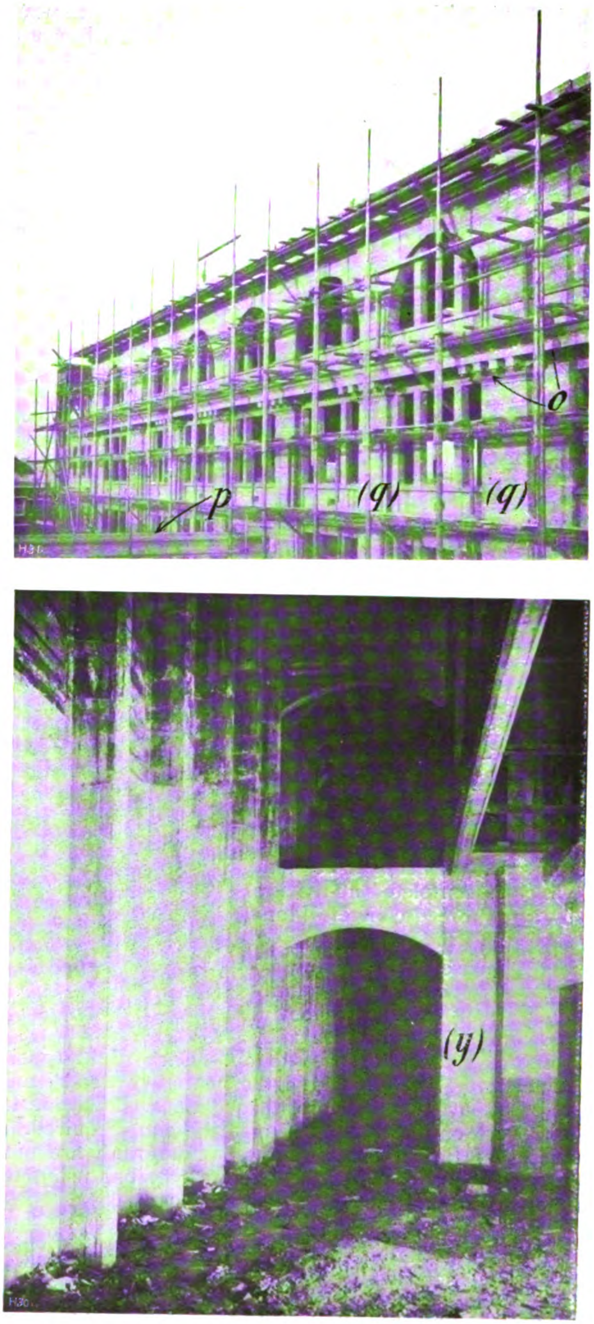
Numbers of beams in the floors and walls of the new buildings are of very long spans, such as would be impracticable in the case of steel, owing to the heavy cost and great depth necessary. In reinforced concrete the employment of beams in long spans is rendered easy by the continuity of adjoining members, the great resistance added by the floor and wall slabs, and the unequalled strength and rigidity of the new structural material. Many of the floor beams in the Post Office buildings have the clear span of 39 ft., and some of the larger beams are in spans up to 50 ft. between supports.

One remarkable structural feature in the Sorting Office block is the cantilever projection of all storeys above the ground floor over the delivery platforms, where mails will be loaded up into vans and carts. The appearance of the building at that place is rather startling, as the upper portion hangs out for the distance of 15 ft. beyond its supports (*see* loading-platform, general plan).

The projecting portion is finished by corbels, which appear to carry the load, and actually do carry a small portion of it, but practically the whole of the work is done by the beams of the floors, aided by the columns and wall slabs, all these members converting the overhanging part of the building into one gigantic cantilever.

SOME DETAILS.

In the present article we illustrate some other interesting details of the new buildings by views taken from photographs and notes furnished by Mr. de Vesian, M.Inst.C.E., of Messrs. L. G. Mouchel & Partners, Ltd.



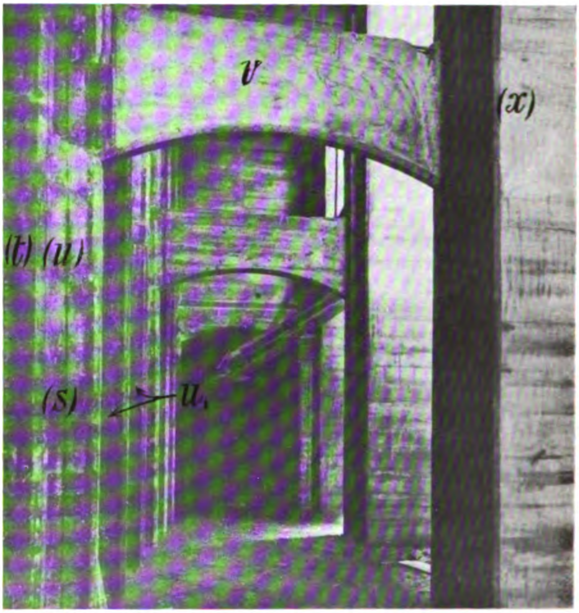
GENERAL POST OFFICE EXTENSION. FIGS. 5 and 6.

Fig. 1 is a view showing the reinforced concrete skeleton in the façade of the Public Office Block in King Edward Street. The skeleton has been left bare, as shown, for the addition of thin granite curtain walls, making the exterior harmonise with that of the old Post Office buildings on the eastern side of the street. All the wall columns (*a*) in the middle portion of the three upper storeys are carried by cantilever projections (*b*) of the main beams lettered (*c*) in *Fig.* 2.

At the left-hand of the photograph, *Fig.* 1, the reader will see one of the numerous ventilation ducts (*e*) provided throughout the building. This duct is formed by 3-in. walls and demonstrates the suitability of reinforced concrete for architectural requirements.

Near ground-floor level are four slits 15 ft. wide for the reception of letters posted by the public. The slits communicate with "letter boxes," whose sides are formed of 3-in. reinforced concrete slabs, each box being, in fact, a large-sized room.

Figs. 2 and 3 are interior views on the ground and first floors respectively of the Public Office Block. It should be mentioned here that, in addition to the strain coming on the cantilever ends of the beams (*c*) and the dead and live loads of the first floor, each of the same beams is subject to the enormous load of 300 tons communicated by the columns (*h*) *Fig.* 3 supporting the floors above. These loads are concentrated at points between (*f*) and (*g*) in all the beams, which, in consequence, are of exceptional strength.



General Post Office Extension. Fig. 7.

A detail in *Fig.* 2 deserving notice is the conformation of the hollow beams (*i*) whose sides are only 4 in. thick, having been designed specially to comply with the scheme of decoration, which calls for the formation of square panels in the plaster ceiling to be added.

Fig. 4 is part of the side elevation of the Public Office Block. The façade here will be completed by brick curtain walls carried entirely by the reinforced concrete skeleton, which is completed at the top by a reinforced concrete Mansard roof (*n*).

The several flights of stairs (*j*) constitute an admirable proof of the wonderful aid offered to architects by reinforced concrete construction. Each flight consists of a single slab of reinforced concrete, $3\frac{1}{2}$ in. thick, and the necessary treads, and has no other support than that afforded by two reinforced concrete walls, 6 in. thick, as (*l*) and (*m*) *Fig.* 4, no stringers or intermediate supports being required. The struts (*k*) and various other pieces of timber shown by the photograph are merely parts of the temporary rails erected to provide for the safety of persons using the stairway before the addition of the curtain walls.

Fig. 5 illustrates part of the two upper storeys of the Public Office Block as viewed from behind the building. On this façade the walls are entirely of reinforced concrete, with the normal thickness of 6 in., but made 12 in. thick in parts where necessitated by decorative exigencies. The broad piers (*q*) really consist of a square reinforced concrete column with a ventilation shaft on either side, as represented in *Fig.* 6 (*y*).

The piers are finished at top floor level by capitals, with dentils projecting beneath the broad cornice which extends in an unbroken line beneath the windows. These details show the adaptability of reinforced concrete to ornamental construction.

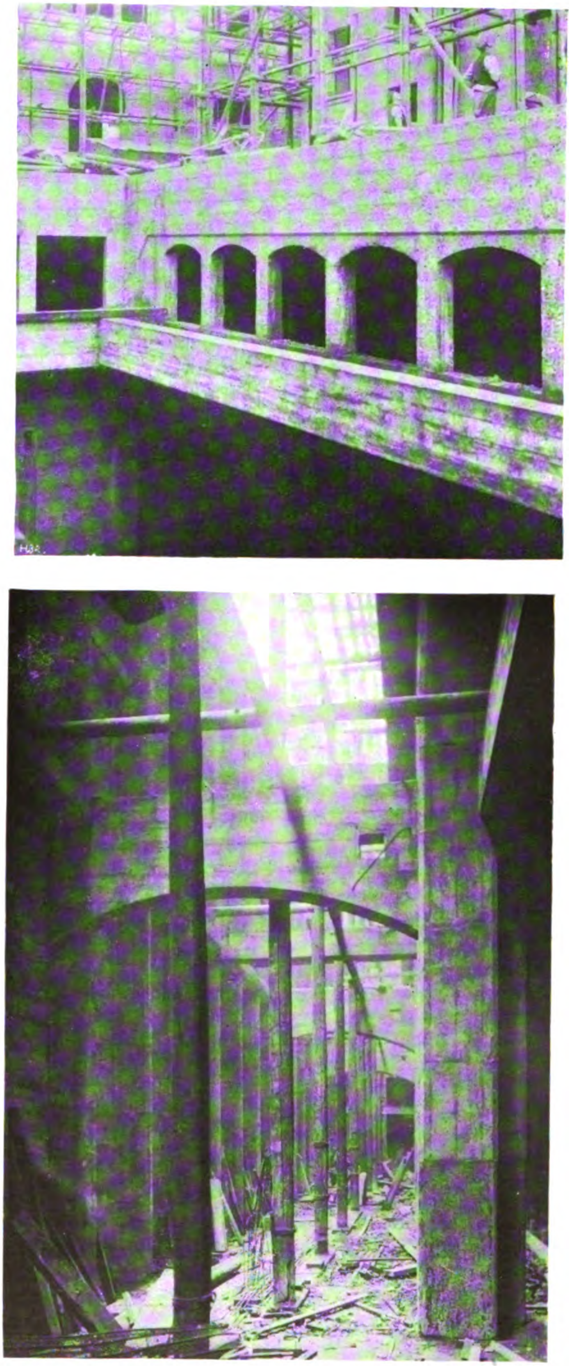
At (*p*) in *Fig.* 5 may be seen the upper part of the reinforced concrete covered bridge connecting the Public Office and Sorting Office Blocks. The structure in question is an interesting study, as, in spite of the fact that the span is more than 50 ft., the sides are only 5 in. thick and consist of tension and compression flanges connected by vertical web ties. The two sides are joined at the bottom by a floor, and at the top by a roof, the four structural elements constituting a monolithic box girder with open web sides.

As a final illustration of the Public Office Block we give, in *Fig.* 7, a view in the basement, where (*s*) is part of the reinforced concrete retaining wall, 28 ft. high, and consisting of a slab (*t*) only 7 in. thick, stiffened at intervals of 6 ft. apart by vertical ribs, or counterforts (u) and (u_1), measuring 8 in. by 16 in. in cross section.

The portion of the retaining wall here shown is along King Edward Street, and has not only to withstand the horizontal earth pressure, but also the pressure due to traffic along the street. Most of the counterforts, as (u_1), are really vertical beams, fixed at one end to the foundations and at the other end to the main beams of the ground floor. The remaining counterforts, fixed in the same way, are divided into two vertical spans by the arches (*v*) which occur at each pier (*x*).

The piers are hollow reinforced concrete box columns, with sides from 8 in. to 10 in. thick, and have to carry the whole weight of the stone facing as well as a very considerable share of the floor loads.

Turning now to the Sorting Office Block, we have in *Figs.* 8 and 9 two views which show the construction of the retaining wall, the dimensions of which are the same as those stated above.



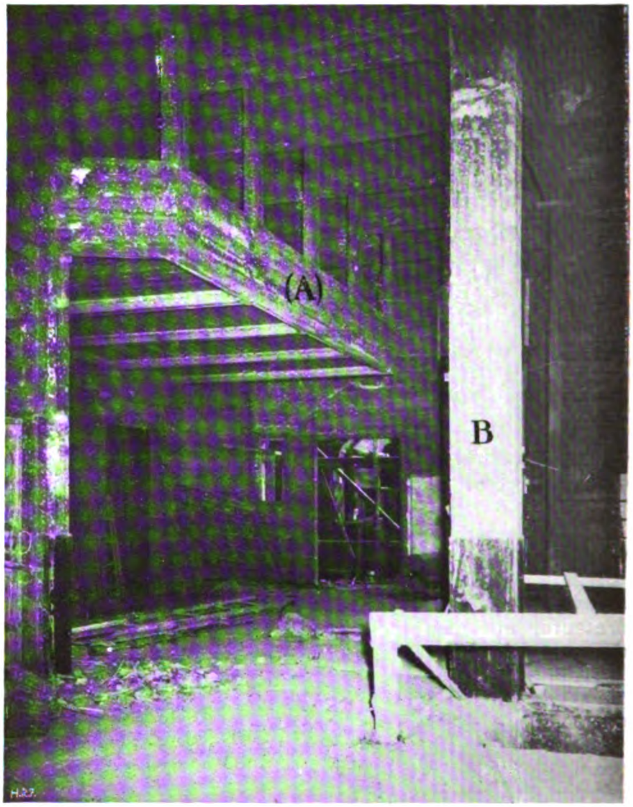
General Post Office. Reinforced Concrete Extension.
Figs. 8 and 9.

In *Fig.* 9 is shown one of the reinforced concrete piers carrying the reinforced concrete front walls above the level of the sub-ground floor, as well as a proportion of all floor loads. Like the piers illustrated in *Figs.* 5 and 6, these members comprise a reinforced concrete column with a ventilation shaft on either side, as shown in *Fig.* 10.

Fig. 8 is a good illustration of heavy girder construction, the member shown being of the pierced web type and having the clear span of more than 50 ft. between supports. It was constructed to carry a roadway over the boiler-house in the great underground building.

The Sorting Office Block contains some halls of magnificent proportions, where hundreds of men will be engaged before long in dealing with letters and packets of all kinds sent by letter post. In order to provide more amply for supervision, numerous "watching galleries" are provided in the sorting halls, where inspectors will be enabled to keep an eye on operations without being observed themselves.

Fig. 10 is a view where (*A*) represents one of these galleries, all of which are carried by beams suspended at the outer end by reinforced concrete ties connected with the main floor beams above. This ingenious device does away with the necessity for columns which would constitute a considerable obstacle on the main floor.



General Post Office, Reinforced Concrete Extension. Fig. 10.

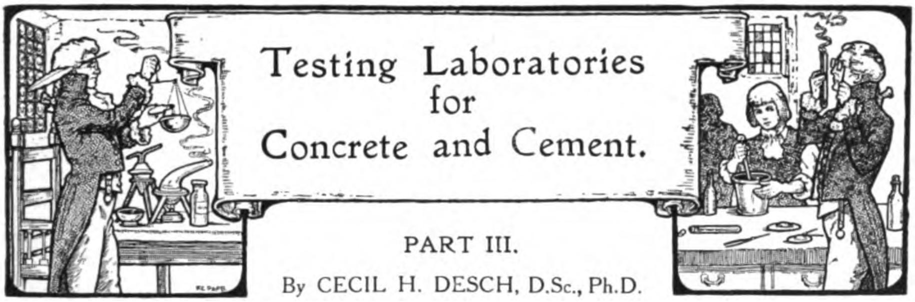
The column lettered (*B*) is one of the members which extend in graduated dimensions from foundations to roof. In the basement, the section of the column illustrated is 28 in. square, and the total load it there has to carry amounts to upwards of 800 tons.

In conclusion, we may appropriately refer to the results of some recent tests in the Sorting Office Block. The area selected for the purpose was a portion of the ground floor, measuring 40 ft. by 35 ft., and supported by six secondary beams 8 in. wide by 18 in. deep, the connecting slab being $3\frac{1}{2}$ in. thick. Each of the beams is reinforced by four $1\frac{7}{8}$-in. dia. bars in tension, two $1\frac{1}{8}$-in. dia. bars in compression, and a number of the usual stirrups. The slab is reinforced by $\frac{3}{4}$-in. dia. bars in two series, forming a rectangular network.

The floor was designed for the normal superload of 1 cwt. per sq. ft.; the test load was $1\frac{1}{2}$ cwt. per sq. ft.; and the specification demanded that the maximum deflection at the middle of the beams should not exceed 1-600th of the span.

On the occasion of the official tests the maximum deflection at the middle of the 40 ft. beam spans was only 5-16th in., or, taking the net distance between supports, only 1-1,500th of the span, or two-fifths the deflection permitted by the specification.

This evidence of rigidity, taken with the fact that the floor resumed its original form after removal of the loading constitutes one more testimony to the strength and elasticity of reinforced concrete construction as here designed on the Hennebique system and the excellence of the work done by the contractors.



Testing Laboratories for Concrete and Cement.

PART III.

By CECIL H. DESCH, D.Sc., Ph.D.

The absence of an official laboratory devoted to investigations with concrete and cement may be said to account in no small degree for the dearth of reliable data as to reinforced concrete as designed and executed in this country.

Some testing station enjoying official support, or if conducted as a private enterprise enjoying the reputation of absolute reliability, would be very much in place at the moment, and it might be a matter worthy of the attention of the Concrete Institute to consider the possibility, and ways and means of obtaining for the British Empire some laboratory of this description.—ED.

WHEN we turn from English laboratories to those of the Continent we meet with an entirely different condition of things, the outstanding feature being the connection, especially of the German and Swiss laboratories, with great national or municipal institutions. The two laboratories selected for detailed description here will be those at Gross-Lichterfelde, near Berlin, and at Zürich. Both are State institutions, and both are more or less connected with technical instruction, the one having working arrangements with the vast Technical School of Charlottenburg, the other forming an institute or department of the great Swiss Federal Polytechnic at Zürich. The establishment of testing laboratories in connection with educational institutions is also gaining ground in this country, notably in the cases of the Municipal Technical School at Manchester and of the new University buildings at Birmingham. But their object is primarily the instruction of students, their industrial uses, although of growing importance, still being secondary, this being the reverse of the condition in the German and Swiss laboratories mentioned.

THE LABORATORY AT GROSS-LICHTERFELDE (BERLIN).

By far the largest testing laboratory in the world is the Königliche Material-Prüfungsamt (Royal Station for Testing Materials) at Gross-Lichterfelde, near Berlin. The present buildings date only from 1904, when the institution was moved from its older quarters in Charlottenburg. The dimensions of the site are about 930 ft. × 615 ft., and on it stand the laboratories, power houses, etc., and residences for the director and assistants, leaving a considerable area free for temporary erections and for open-air experiments. The main building occupies three sides of a long quadrangle, of which the central block is mainly devoted to administrative and other offices, the laboratories being housed in the wings. The area of this building is nearly 60,000 sq. ft. The workshops form another block, lying between the two wings, and there are several smaller detached buildings.

The Testing Station has grown up under the leadership of a single director, Prof. A. Martens, to whom the testing of materials owes so much, and the equipment bears throughout the impress of his activity. Most of the appliances have been either designed or modified by him; and his influence, and that of the group of workers he has gathered round him, amongst whom Prof. Gary should be specially mentioned, are to be traced wherever tests of a mechanical character are made.

The Station has, in the first place, to carry out investigations of an original character, the results of which are of general utility for industry; in the second place, to make routine or special tests, either for public bodies or for individuals, fees being charged for the work; and, in the third place, to provide instruction for students. The judgment of the institution, as an impartial authority, is also frequently invoked by the law courts in technical cases. The range of material dealt with is very wide, including metals, building stones, cement and concrete, bricks and earthenware, lubricants, paper, rubber, and many other substances. It will be sufficient to confine the present description to the department dealing with cement and concrete. This section includes a chemical laboratory in which complete chemical analyses may be made, attached to which is a mineralogical laboratory for the microscopic investigation of stones, clinker, etc. The tests of setting time and of constancy of volume are made in the physical laboratory. For the former, both the Vicat needle and Prof. Martens' automatic needle, with recording device (CONCRETE, Vol. I., p. 436), are used, as well as Prof. Gary's fundamentally different method, depending on the measurement of the development of heat during setting (CONCRETE, Vol. I., p. 350). The constancy of volume is tested with the Bauschinger micrometer and with the Martens recording micrometer, the latter making a continuous photographic record of changes in length.

The mortars are mixed in Steinbrück-Schmelzer laboratory machines, and all briquettes are rammed with Böhme mechanical hammers, fitted with an automatic arrangement for stopping when the prescribed number of blows has been given. This ensures the uniformity of the briquettes.

The great feature of this department, however, is the array of mechanical testing machines. In addition to the small tensile machines there are presses of 20, 30, 40, 150 and 400 tons, of which the smaller are used for cement cubes, the intermediate sizes for concrete cubes, and the largest for columns and beams. All these machines are of Prof. Martens' own design and were constructed by the Nürenberger Maschinenbau-Gesellschaft. The pressure is supplied from a central hydraulic power station, using two electrically-driven pumps. There is also a 33-ton press, constructed by Amsler-Laffon & Son, and a large machine for testing floor panels up to 20 ft. x 10 ft. This machine is provided with special arrangements for different forms of panel and different distributions of load.

There is an apparatus, designed by Prof. Gary, for tests of permeability of concrete to water. Fire tests are also undertaken in huts on the open part of the site, but curiously this department of the Gross-Lichterfelde work is still conducted on somewhat primitive lines, and in no way equals in thoroughness what we are used to at the British Fire Prevention Committee's testing station near Regent's Park. In this one particular direction the German testing equipment can in no way compare with that of London.

The important department for the testing of metals is so far of interest to constructors in reinforced concrete that the elastic properties and tensile strength of the iron and steel required by them for reinforcing purposes are determined there. The principal testing machine is of the horizontal pattern and is capable of taking specimens up to nearly 50 ft. in length in tension or compression, under loads up to 500 tons. This gigantic machine was built by Hoppe, of Berlin. Elaborate provision is made for the measurement of elastic and inelastic deformations of every kind.

This very brief account will give some idea of the equipment of this great laboratory, which has been at once the pioneer and the example of all subsequently established institutions.

In recent years very interesting and important investigations in connection with reinforced concrete have been made in the Gross-Lichterfelde testing laboratory, as also in the testing laboratories connected with several of the other German technical colleges. Those undertaken at the Technical High School at Stuttgart, under the direction of Prof. C. Bach, are especially notable, and the results are being published in a series of special memoirs.

THE LABORATORY AT ZÜRICH (SWITZERLAND).

The Laboratory for Testing Structural Materials at Zürich rose into importance under Prof. Tetmajer, and has increased still further in activity and usefulness under its present director, Prof. F. Schüle, one of the foremost authorities on the strength of materials. The laboratory occupies a separate building in the quarter of the town devoted to the Institutes of the Polytechnic and of the University. Since it is now undergoing considerable rearrangement and enlargement the present description can only be regarded as to some extent provisional.

The physical methods adopted at Zürich for the examination of cement are in some respects simpler than those in use in other laboratories. For instance, the Vicat needle is exclusively employed in determining setting time, both automatic needles and thermal methods having been abandoned after considerable trial. The latter, whilst admirable in principle, are found to be so largely dependent on the mass of cement taken for the test as to be less valuable for practical purposes than the simple and easily applied needle test. The flourometer has also been given up for the determination of the quantity of impalpable powder in a cement, stress being laid rather for the determination of fineness, on careful sifting tests and on the measurement of the litre-weight with mechanical filling arrangements. The constancy of volume, also, is mainly judged from the appearance or non-appearance of cracks or warping in thin cement pats having one side accurately flat. Concrete prisms, however, are tested for constancy of volume by measuring the distance between two embedded glass datum marks from time to time with a reading microscope. These experiments are continued over long periods, and the amount of space provided for storage in air and in water is, therefore, large.

Briquettes are mixed by hand, this method being found perfectly trustworthy when experienced workmen are employed. The proper proportion of water is determined by a preliminary test, and the mixing is continued for a fixed time. Comparative experiments with a laboratory mixing machine have shown no difference between the two methods. The ramming of the briquettes is, however, always accomplished mechanically, the machines installed being unlike the Böhme hammer, and resembling rather small pile-drivers, the stoppage after a fixed number of blows being automatic. Cubes for compression are made in the same way.

Tests on concrete form a large part of the work of the laboratory, and provision is therefore made for preparing concrete blocks, beams and structural members on a large scale. For testing purposes several Amsler-Laffon presses are in use, and certain of the metal-testing machines can be adapted to tests on concrete and cement. As at Gross-Lichterfelde, the machines in this department are supplied with water under high pressure from central hydraulic pumps.

The largest machine, and that which marks the most important departure in the testing of structural members, is that for testing beams up to 13 ft. in length under distributed load, the load being applied at seven equidistant points by independent rams, all of which are under the same pressure. This machine, constructed by Messrs. Amsler-Laffon, was described and illustrated in CONCRETE (Vol. I., p. 376) in an article dealing with tests by Prof. Schüle on reinforced concrete beams. The cylinders of the rams are placed vertically, and the beam rests on them, being held at the two ends by cross-pieces above, fitted with roller bearings. In making a test, the sides of the beam are whitewashed, and each crack as it appears is marked on the surface, the end of the crack, after each increment of load, being also marked. This provides a very complete survey of the distribution of stresses during bending. The same machine may be utilised for tests on short beams, or for crushing tests on concrete water-pipes or sewers, by erecting a movable cross-piece, so that only two or three rams are used, the remainder being disconnected from the pump. A travelling crane running the whole length of the testing room facilitates the fitting up of such arrangements.

Tests of the permeability of concrete and of its behaviour after repeated freezing and thawing are also made. The chemical work, for which an excellent laboratory is provided, has been so far confined to the analysis of cements and other materials. A microscopic installation is in use for the examination of metals, and some experiments have been made on the application of the microscope to the study of cement. This method, which is still very imperfectly developed, is receiving considerable attention at the present time at Gross-Lichterfelde, and also in Italian laboratories.

LABORATÓRIES IN VIENNA AND PARIS.

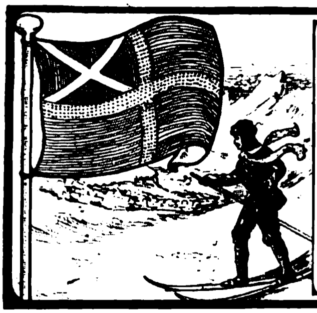
Of the numerous other public Testing Stations on the Continent it is sufficient to mention two—the recently equipped laboratory in Vienna and that of the Conservatoire des Arts et Métiers in Paris, both of which are celebrated for their completeness in certain directions, but many others are capable of carrying out extended researches and of affording assistance to the industries concerned.

SUMMARY.

There can be no doubt that the rapid progress in the knowledge of reinforced concrete construction which has been seen on the Continent in recent years is, to a very large extent, due to the work of such laboratories as those described. Their close connection with public bodies has enabled these to utilise the new methods of construction when desirable, without the risk attaching to untried systems. Thus, the Ministries concerned with the erection of public buildings, State railways, municipalities and other corporations have utilised reinforced concrete wherever it has been possible, receiving constant advice from the laboratories, and in turn placing the practical experience thus acquired at the service of the scientific directors for use in further investigations. This co-operation has been of benefit to all, and it is from its extension that further advances are to be looked for. Progress in methods of construction must come from the experience of practical men and from the experiments of qualified scientific investigators, and the services of both are indispensable.

A subsequent article will deal with some American laboratories.

(To be continued.)



REINFORCED CONCRETE IN SWEDEN.

By GEORG BROCHNER, Copenhagen.

(Free Translation of the Author.)

We have previously dealt with the Historical Evolution of Reinforced Concrete in various countries, in the United States (Vol. I., No. 2), France (Vol. I., No. 3), Germany (Vol. I., No. 5), Italy (Vol. I., No. 6), Switzerland (Vol. II., No. 2), Austria (Vol. II., No. 4), Holland (Vol. II., No. 5), Hungary (Vol. III., No. 2), Denmark (Vol. III., No. 5), and we are continuing the series by an article giving some examples of work in Sweden.

It is our intention to present further articles dealing with other countries, so that the series when complete may take the form of what will be practically a Universal History of the Development of Reinforced Concrete with notable examples.—ED.

Although Sweden perhaps was somewhat slow in adopting reinforced concrete as a constructive factor of more general importance, the last few years have witnessed a number of interesting works in this material, and there is every reason to expect that it is destined to play a prominent and comprehensive part in the future. Apart from its application in house and factory construction reinforced concrete is likely to find a wide field in connection with the numerous large hydro-electric installations which are already projected in Sweden.

We must defer discussing matters of legislation on the present state of the regulations in Sweden for another occasion, as also reference to the interesting buildings above ground which have been erected in this country, but having regard to their peculiarity we are now taking the opportunity of describing some of the reinforced concrete work executed in connection with water power schemes.

Thus we would specially refer to the works of Messrs. Vattenbygnadsbyran, of Stockholm, who are specialist engineers for hydraulic work, and who are developing the use of reinforced concrete in connection with reservoirs and other water power schemes, a matter which does them great credit.

Among the many important works of this character already completed under the supervision of this firm is the large dam at the Gullspang Water Power Station (capacity about 21,000 horse power) at the N.E. corner of the Lake Vänaru. This dam consists of three portions—viz., a solid concrete dam at each river side to a depth of about 40 ft.; beneath the crown of the dam and between these two an arch-dam with 130 ft. outer radius, 10 ft. thickness, and greatest depth 63 ft. It was first intended to construct the arch entirely of reinforced concrete, but the construction ultimately chosen was a combination of plain and reinforced concrete. The haunches of this arch, which are protected by means of stones piled up at the back, consist of solid concrete, whilst the upper portion of the arch is reinforced concrete. The intermediate pillars are also reinforced concrete. The piled-up stones, by-the-bye, are intended to protect the back of the dam, to counteract the effect of the great changes of temperature which occur on the Lake Vänaru, and also to prevent the bottom from being washed away beneath the dam. Perhaps we should add that reinforced concrete is also used on these works for the large open turbine chambers.

Near Gullspang the firm we refer to above has also constructed a road bridge of reinforced concrete, the reinforcement comprising longitudinal ¾-in. and ½-in. irons, with ½-in. distributing irons at 1½ ft. apart, connected by means of plate-iron links. The bridge has a clear span of about 87 ft., and the old bridge, which it was necessary to pull down on account of the water level being raised by the building of the Gullspang dam is shown on our illustration behind the new bridge.

The distribution basin at Ringdalen in Northern Sweden, completed in 1907, had a reservoir constructed as an intermediate basin between the inlet canal and the six turbine chambers. This intermediate basin, which was built of ordinary concrete, had its front carried down to a firm rock bottom, whilst the wings were partly built on a loose water-carrying sand. From leakage in the bottom of the reservoir, or from some other cause, the loose sand beneath one of the wings was partly washed away, and a collapse resulted.

Messrs. Vattenbygnadsbyran were then commissioned to design a new basin and to superintend its construction. It was decided only to retain the front wall which had been carried to the firm bottom, but this wall was strengthened. The side walls, however, had also to be carried down to a firm bottom, and in order to prevent the water from cutting away underneath these walls a frame wall of iron beams (after the Larsen system) has been constructed, and the connection with the canal was improved by means of clay puddle, protected on the outside with a layer of stones.

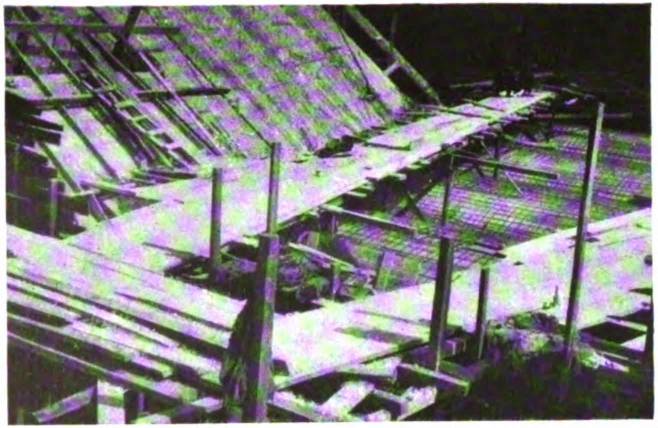
Reinforced Concrete Viaduct at Sandviken.

The bottom of the reservoir is double, and consists of ordinary reversed arches, which, by means of concrete walls, support the reinforced concrete upper arches which form the bottom proper. By this arrangement one is enabled to inspect both the state of the ground underneath the reservoir and also the state of the bottom itself.

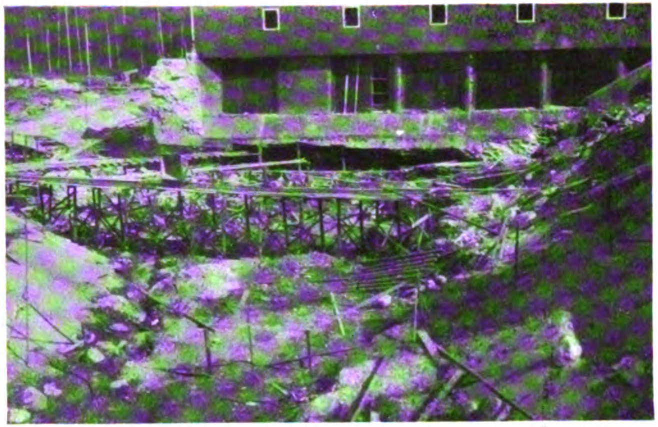
The side walls, which are of reinforced concrete, now stand on solid concrete pillars. Where the new side walls join the old front wall, expansion joints have been adopted. The front wall has been strengthened by means of a longitudinal reinforced concrete beam.

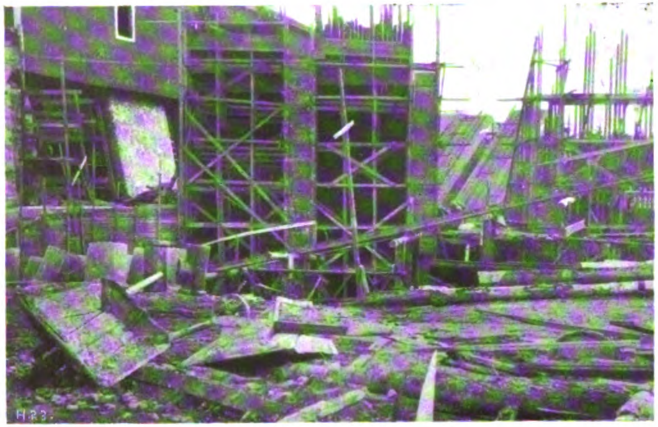
The whole interior of the reservoir has been covered with cement, which has been twice coated with "siderostene"; earth has been filled in outside the side walls. The installation has again been in operation for some time, and the reservoir has proved completely water-tight. The work was executed by Messrs. Hoyer, Elleisen, Stockholm.

Bottom arches.

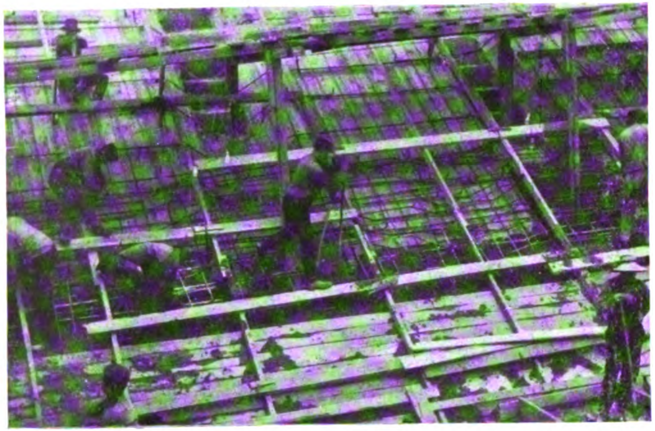


Showing the old wall.





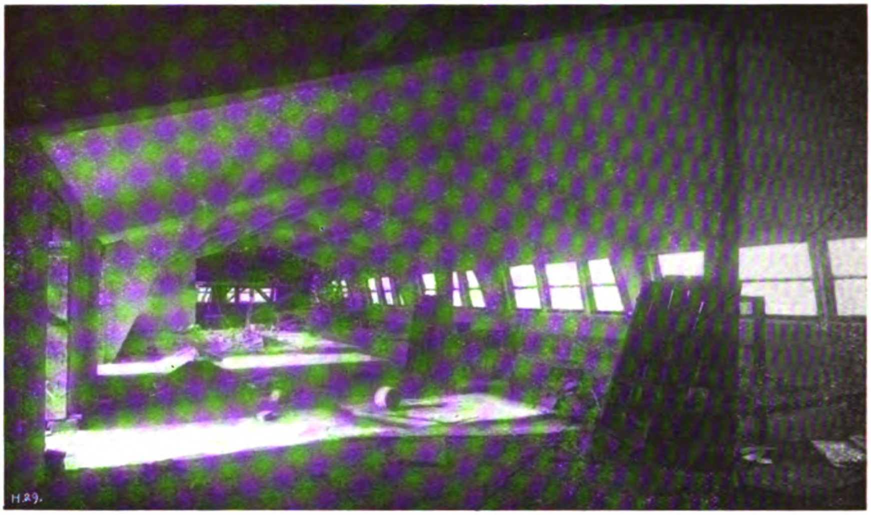
New reinforced concrete side wall in course of construction.



Placing reinforcement.

REINFORCED CONCRETE DISTRIBUTION BASIN AT RINGDALEN.

Reinforced concrete has also been used for the walls of the turbine chambers at the Jössefors Water Power Station in West Sweden. The front wall has the shape of a half cylinder, and is close upon 1 ft. thick. The iron reinforcement is calculated so as to be able alone to receive the pulling strain in case a crack should arise in the concrete. The actual strain on the concrete is very materially below the permissible figure, but it has not been found expedient to make the wall any thinner. The side walls are 2 ft. 6 in. thick, and are reinforced, with a view of being attached to the bottom of the basin and connected to the front wall face. This connection has been made in three places by joining the walls with reinforced concrete beams, which are connected by means of horizontal reinforced bands inserted



Interior of Reinforced Concrete Factory for L. M. Erikson & Co., Stockholm.

in the side walls. The reinforced beams are also calculated to be able to stand the pressure from the gate posts and guards, which are found at the inlet to the chambers.

The chambers are polished inside and coated with "siderostene," and in the water line there is stone lining.

Similar turbine chambers are now being constructed at the Torsebro Power Station in South Sweden, and they will undoubtedly be used to a considerable extent at waterfalls with a height of fall from 20 to 40 ft.

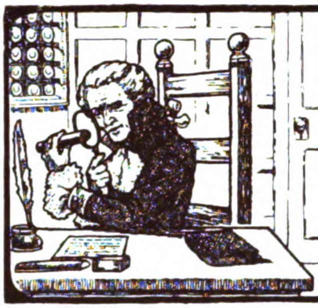
For building purposes reinforced concrete is now getting into more general use, and some very important structures, both factories and domestic houses, have recently been erected in which reinforced concrete has played a most essential part. To these we shall refer on a later occasion.

Mention might, however, be made of one example where the Skanska Cementgjuteriet, Stockholm, has installed reinforced concrete beams, staircases, and outer roofing in the new imposing factory of L. M. Erikson and Co., Stockholm, a corner building facing two streets and with eight storeys; it covers an area of 860 sq. m.

The first three storeys have beams calculated for a live load of 1,500 kgs. per sq. m., the following three for a load of 800, and the upper floor for a load of 400 kgs. per sq. km. The outer roofing is on the outside covered with plate iron on wooden panelling, and the flooring is partly cement and partly wood. The building is about to be extended, and reinforced concrete will be used to the same extent in the new addition as in the present factory.

Amongst other engineering works recently constructed in Sweden is the Viaduct at the Sandviken Station, near Gefle; the Viaduct is entirely built of reinforced concrete, and is 25 ft. broad, of which the carriage road amounts to 18 ft. The footpath is built on bracket beams outside the main beams of the Viaduct. The portion of the Viaduct leading across the railway consists of two spans, each about 53 ft broad; there are 16 sections resting on columns, and the total length of the Viaduct is 416 ft., and it is calculated for traffic with motor-cars of 10 tons weight. It was completed in 1907.

REINFORCED CONCRETE BRIDGE AT GULLSPANG.



REPORT OF THE SPECIAL COMMISSION ON CONCRETE AGGREGATES.

The Interim Report on Materials used for Concrete Aggregates is dealt with below, and we hold the series of specifications for the different aggregates to be most useful.—ED.

WE have received the Interim Report of the Special Commission on Concrete Aggregates, appointed by the British Fire Prevention Committee.

This Interim Report comprises a general summary as to the constitution and work of the Commission, and indicates what the Commission considers necessary in the way of an extension of its reference; but above all it points to the tests or research work essential for the completion of its enquiry.

Attached to the Report is a schedule indicating the aggregates which the Commission desires to enquire into, and this schedule is most valuable, inasmuch as it presents a carefully thought out series of specifications of the materials in common use as aggregates in this country. These carefully drafted specifications have long been wanted, for at present nearly every Government Department, municipal authority or professional man in private practice uses some particular form of specification, and many of these forms neither express what the users require, much less what they should require for the purposes of a good concrete. Standardisation in the specification of concrete aggregates is most desirable; and, although these specifications, as presented as a schedule to this report, are not yet quite complete—for, as the report points out, the Commission still requires certain additional data only obtainable by research—the sheet before us marks a step in the right direction, and deserves the closest attention of all interested in concrete work.

Regarding the general tenor of the Interim Report, it is needless to say we are in full agreement with the proposed research work regarding concrete aggregates, and we trust that the ways and means will be found to conduct the necessary investigations.

The Commission was formed at a time when there was no Concrete Institute in existence, and when the British Fire Prevention Committee, who appointed the Commission, were only desirous of obtaining data as to concrete aggregates useful for fire-resisting floors. We observe that the Interim Report points to the advisability of extending the reference "to other purposes" other than floors, and also suggests the advisability of co-operation with the Concrete Institute, which body is, of course, a suitable centre for all enquiries of this description.

If, as the Report suggests, certain tests can be undertaken by the Concrete Institute, as far as crushing tests and the tests as to the holding power of rods in concrete are concerned, and if the British Fire Prevention Committee were to undertake the fire tests, and the results obtained by both societies properly compiled, we should certainly in a few years' time have all the data that we require. The investigation would, however, be a very extensive one.

Regarding the specification of materials for aggregates, we cannot do better than simply quote what the report says.

In conclusion we would only add that the Special Commission, which was formed entirely from among the members and subscribers of the British Fire Prevention Committee, is a most authoritative one, and that it was constituted as follows:—

Chairman : Sir William Preece, K.C.B., F.R.S., Past Pres. Inst.C.E., late Chief Engineer.

Deputy Chairman : Edwin O. Sachs, F.R.S. Ed., Chairman Brit. Fire Prevention Committee.

Chairman of Research Sub-Committee : W. T. Hatch, M.Inst.C.E., Chief Engineer (representing Metropolitan Asylums Board).

Chairman of Specifications Sub-Committee : Max Clarke, F.R.I.B.A.

Hon. Secretary : Matt Garbutt, F.R.I.B.A.

Representing the Admiralty : C. H. Colson, M.Inst.C.E., Supt. Civil Engineer.

Representing the War Office : Col. A. H. Bagnold, R.E., Supt. of Building Works at Woolwich ; Major R. N. Harvey, D.S.O., R.E.

Representing the Norwich Corporation : A. E. Collins, M.Inst.C.E., City Engineer.

H. K. G. Bamber, F.C.S.

F. S. Capon, Assistant Architect, London County Council.

J. Herbert Dyer, Senior Vice-President, National Fire Brigades' Union.

F. W. Hunt, F.R.I.B.A., Portman Estate.

W. H. Hunter, M.Inst.C.E., Chief Engineer, Manchester Ship Canal Company.

Ellis Marsland, District Surveyor (Hon. Sec., British Fire Prevention Committee).

E. G. Rivers, M.Inst.C.E., Chief Engineer, H.M. Office of Works.

Jos. Randall, A.M.Inst.C.E., Contractor.

A. Ross, M.Inst.C.E., Chief Engineer, Great Northern Railway.

J. W. Restler, M.Inst.C.E., Deputy Chief Engineer, Metropolitan Water Board.

James Sheppard, A.Inst.E.E., North British and Mercantile Insurance Co. (deceased).

Frank Sumner, M.Inst.C.E., City Engineer, Corporation of London.

J. Winn, Lieut.-Colonel, R.E., late of School of Military Engineering, Chatham.

Chemist to the Commission : Cecil H. Desch, D.Sc., Ph.D.

The following is an extract from the Report :—

SPECIFICATION OF MATERIALS FOR AGGREGATES.

"The divergency of views as to the correct description of the actual materials in use as aggregates has, however, led the Commission to the decision of publishing at this stage, with this Interim Report the Schedule A attached, comprising a series of Specifications for Artificial and Natural Materials for Aggregates frequently used in this country for Concrete."

"The Specifications issued are for the following—namely :—

Artificial Materials for Aggregates.

1. Coke breeze.
2. Clinker.
3. Blast furnace slag.
4. Broken brick.
5. (*a*) Gault clay burnt.
   (*b*) Ordinary burnt clay ballast.
   (*c*) Broken terra-cotta :—
      (1) Porous.
      (2) Dense.

Natural Materials for Aggregates.

6. Natural ballast (gravel).
7. Volcanic rocks.
   (*a*) Basalts, traps, dense, lavas, etc.
   (*b*) Lavas and rocks of similar character.
   (*c*) Pumice, etc.
8. Crushed granite.
9. Sandstones, limestones, quartzites, and rocks of a similar character.

"The Specifications may be deemed complete with the exception of (α) the percentage of sulphur allowable in certain of the artificial aggregates (β) the weight limits for certain volcanic rocks, and (γ) the porosity of certain clay products, which points can alone be decided after considerable further inquiry and test."

"The tests necessary prior to framing recommendations should be with concretes in which aggregates complying with the Specifications as *now* drafted alone will be used."

"The Specifications as they stand, even without any recommendations, should be found useful, and may lead to standardisation in the description of aggregates."

"As to size to which aggregates should be used to fulfil different purposes, etc., these are also matters for which further research is still necessary prior to the recommendations being framed."

The following comprises the Schedule to the Report :—

ARTIFICIAL MATERIALS FOR AGGREGATES.

1. Coke Breeze.—Coke breeze for use as a concrete aggregate shall be entirely coke taken from the gas retort, coke oven, or special furnace. It shall be absolutely free from clinker, coal, and all substances that will not float in water, and from any admixture of material taken from the retort furnace or water-pan below it, and from cinder, ash, or other admixture. The proportion of sulphur in coke breeze shall not be more than..................per cent.

Note.—It was decided that the determination of the allowable amount of sulphur should be the subject of future consideration.

2. Clinker.—Clinker for use as a concrete aggregate shall be the thoroughly burnt and hard waste product of furnaces, free from dust, shale, or free lime, and not having more than.................per cent. of sulphur.

Note.—Pan breeze is included in this definition.

Note.—In this case, as in that of coke breeze, it was decided that the determination of the allowable amount of sulphur should be the subject of further consideration.

3. Blast Furnace Slag.—Blast furnace slag for use as a concrete aggregate to be obtained and selected from pig iron smelting furnaces (to the exclusion of basic slag), to be of porous quality, to be washed to remove dust and sulphur, to be without free lime, and not to contain more than.................per cent. of sulphur.

Note.—In this case also, it was decided that the allowable amount of sulphur should be the subject of further consideration.

4. Broken Brick.—Broken brick for use as a concrete aggregate shall be from well-burnt and perfectly sound and hard clay bricks, such as London stock bricks, or bricks of equal quality, and shall be of the size specified and be free from old mortar, and from dust or particles that will pass through a sieve of $\frac{1}{8}$-in. mesh.

5. (a) Gault Clay Burnt.—Burnt gault clay for use as a concrete aggregate shall be free from free lime and sulphur and from unburnt particles, and shall be thoroughly hard, so that pieces soaked in water for..................hours shall not disintegrate.

NOTE.—It was decided that the Tests Sub-Committee should be asked to determine the length of time to be inserted in the clause.

5. (b) Ordinary Burnt Clay Ballast.—Ordinary burnt clay ballast for use as a concrete aggregate shall be free from free lime and sulphur and from unburnt particles, and shall be thoroughly hard, so that pieces soaked in water for.................. hours shall not disintegrate.

NOTE.—It was decided that the Tests Sub-Committee should be asked to determine the length of time to be inserted in the clause.

5. (c) Broken Terra-Cotta.—(1) *Porous:* Broken porous terra-cotta for use as a concrete aggregate shall be (*a*) from clean and well-burnt earthenware, unglazed, which has been mixed before firing with some combustible material such as sawdust, so that after firing it is of a porous or cellular texture, or (*b*) from clean and well-burnt unglazed earthenware which is capable of absorbing at least..................per cent. of its own weight of water. (2) *Dense:* Broken dense terra-cotta for use as a concrete aggregate shall be from clean and well-burnt earthen or stone ware, unglazed, and shall be incapable of absorbing more than..................per cent. of its own weight of water.

NOTE.—It was decided that the Tests Sub-Committee should be asked to determine the percentages to be inserted in these clauses.

NATURAL MATERIALS FOR AGGREGATES.

6. Natural Ballast (Gravel).—Natural ballast for use as a concrete aggregate shall be gravel from river beds, sea coasts or glacial deposits, washed, if necessary, to remove dirt, loam, earthy or saline matter, clay, and other foreign substances.

7. Volcanic Rocks.—All rock of volcanic origin for use as a concrete aggregate shall be entirely free from decomposed parts and must show no signs of expansion, disintegration, or dissolution after having been immersed in water for 72 hours.

Rocks of this nature may be divided into the following classes:—

(*a*) Basalts, traps, dense lavas, etc., weighing not less than..................lbs. per cubic foot. These shall be dense, thoroughly vitrified, not scoriaceous, show a clean fracture when broken, be homogeneous and free from marked cellular structure.

(*b*) Lavas and rocks of similar character weighing not less than...............lbs. per cubic foot. These shall be hard and free from all soft or organic matter, but they will not be so hard, and will be more cellular than those of section (*a*).

(*c*) Pumice weighing not more than............lbs. per cubic foot. It shall be hard, free from all organic matter, soft dust or impurity, and show a bright silky structure when broken.

NOTE.—It was decided that the Tests Sub-Committee should be asked to determine the weights to be inserted in these clauses.

8. Granite.—Granite for use as a concrete aggregate shall be obtained from......... ....(*here insert name of quarry*), and shall be reduced to the specified dimensions by crushing or breaking, and shall be close, hard, and of even texture; free from large crystals of felspar, dirt, argillaceous or organic materials, all decomposed particles, and from dust that will pass through a $\frac{1}{16}$ inch mesh.

9. Sandstones, Limestones, Quartzites and Rocks of similar character.—Rocks of these characters for use as concrete aggregates shall be dense, uniform, and homogeneous in structure and composition. They shall have small, even grains, and crystalline texture.* Fractures shall be clean and free from large flaws. The weight of the material shall not be less than 130 lbs. per cubic foot, nor its crushing strength less than 200 tons per square foot, and it shall not absorb more water than 8 per cent. of its weight after immersion for 24 hours. The aggregate after preparation shall be free from all dirt, decomposed rock, argillaceous and organic material.

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* This is not intended to exclude Oolites otherwise suitable.

THE NEW REINFORCED CONCRETE FOUNDRY FOR Messrs. SIEMENS & HALSKE, NONNENDAM (Near BERLIN).

REINFORCED CONCRETE FOUNDRY. (General view in course of construction.)

By H. PRIME KIEFFER, C.E., Berlin.

We are presenting particulars of this reinforced concrete foundry, as foundries are a class of building to which reinforced concrete is particularly applicable.

This foundry has, as a matter of fact, cost only some £5,000 to erect, while the alternative estimate for ordinary steel frame construction and brick walls is stated to have been £6,500.—ED.

To properly describe the history of the new reinforced concrete foundry building of Siemens & Halske would almost necessitate a treatise on German factory management, for in a German concern of this type, with its noted thoroughness and delight in research work, such a step as the application of reinforced concrete to one of its structures was a matter of no small moment, and involved the unravelling of much "red tape."

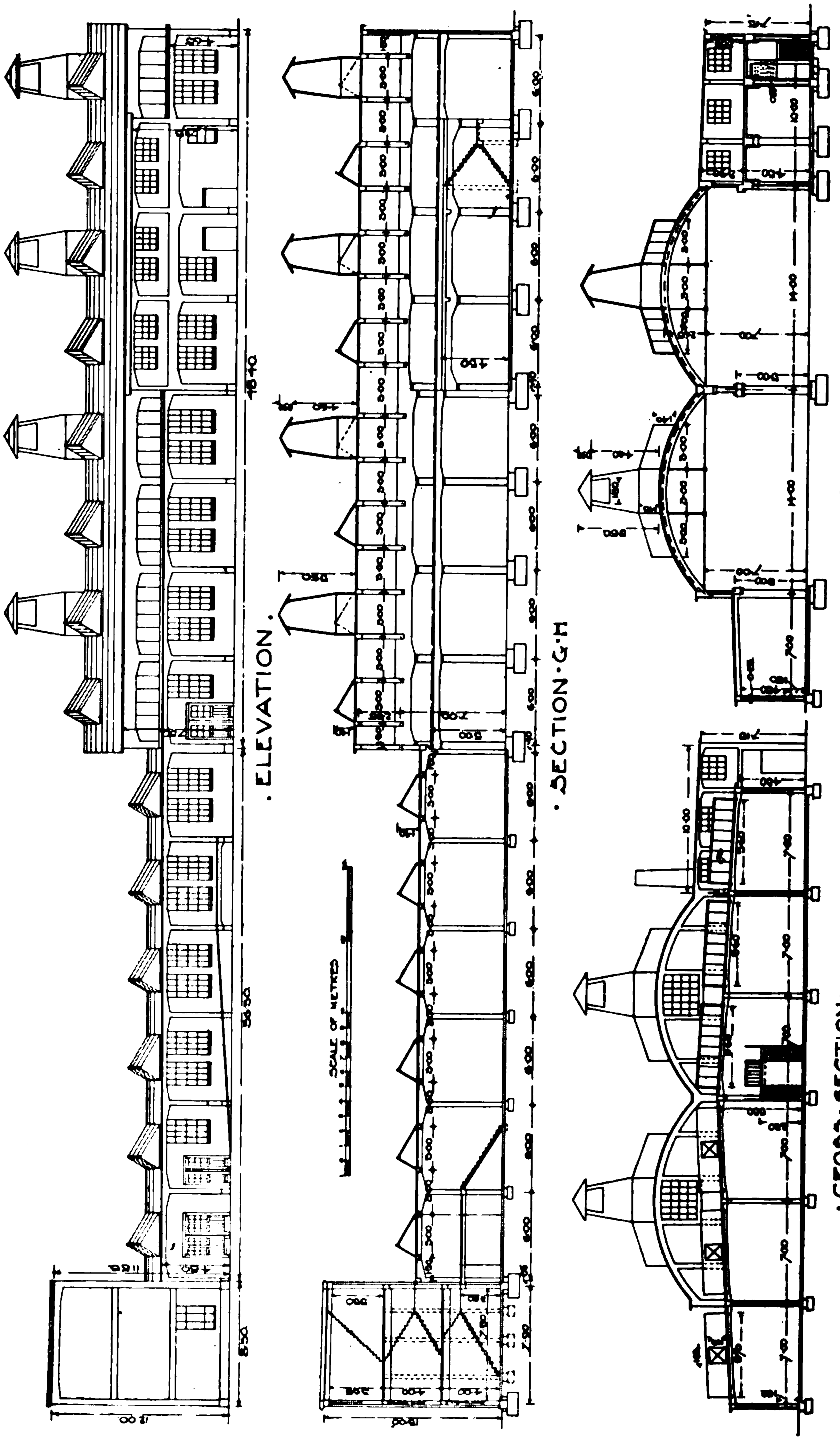
But few readers of this article can realise how many buildings this mammoth German concern has built in Germany and elsewhere, or how, having regard to the large experience of the directorate in buildings of an orthodox character, reinforced concrete was looked at askance. The adoption of reinforced concrete by this German company for even so small a building as the one illustrated was therefore more than a matter of routine, and, in a way, its adoption was a matter of importance in the development of the material as applied on the Continent.

The construction illustrated was erected in the remarkably short period of 70 working days, and it cost M.110,000 (£5,500).

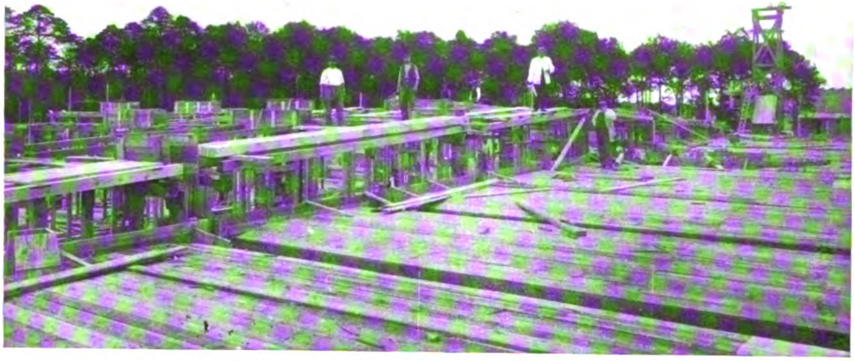
The building is divided into three separate divisions—administrative, workshops, and the foundry proper. It is 137 ft. wide and 302 ft. deep, the administrative block being three storeys high and 26 ft. 10 in. deep; the workshop, one storey high and 117 ft. 10 in. deep; while the foundry is 137 ft. 4 in. deep; these dimensions being centre to centre of dividing walls.

The administrative block contains the foundry offices on the first floor; one-half of the second floor is used for the lockers, baths and wash-rooms of the staff, while the other half contains the staff and dining-room and kitchen. The third floor is used for office purposes. Reinforced concrete has been used throughout except for the wall panels and partitions, which are of brick.

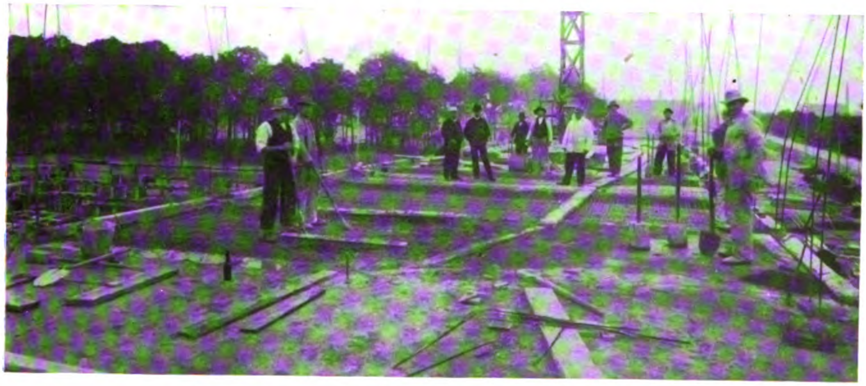
The workshops and storage rooms of the foundry occupy the space immediately behind the administrative block reinforced division. Concrete is here also employed throughout with the exception of the filling of the side walls. The details of girders,



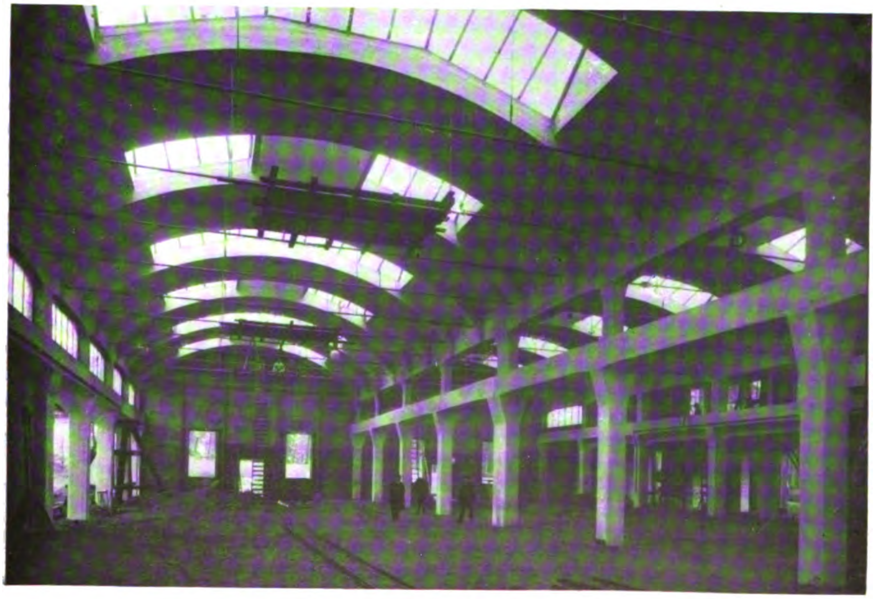
REINFORCED CONCRETE FOUNDRY



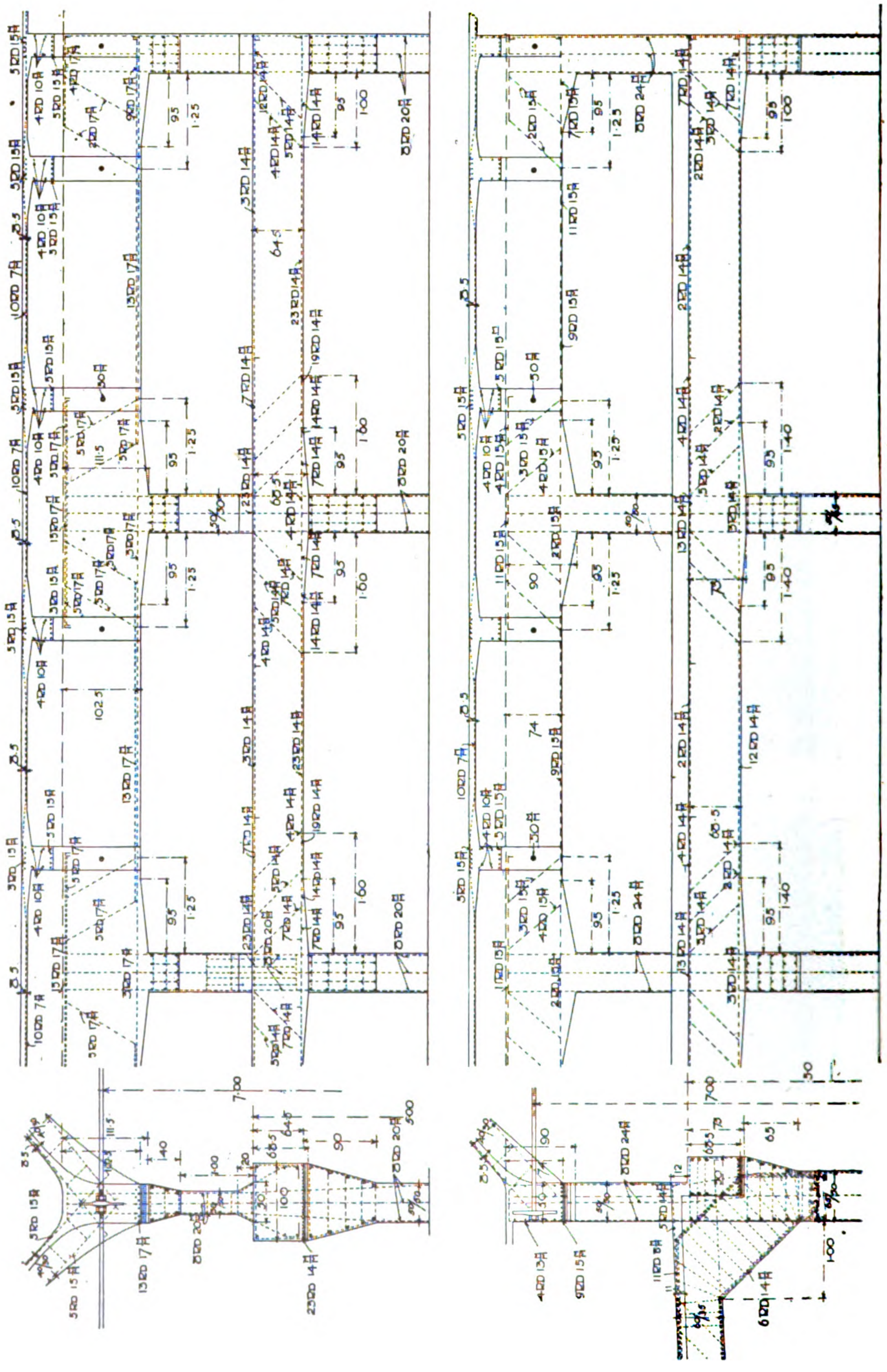
(View showing centering in position for the second floor.)



(Reinforcement of second floor in position ready for concreting.)



(Interior view showing moulded columns and arches.)
REINFORCED CONCRETE FOUNDRY AT NONNENDAM.



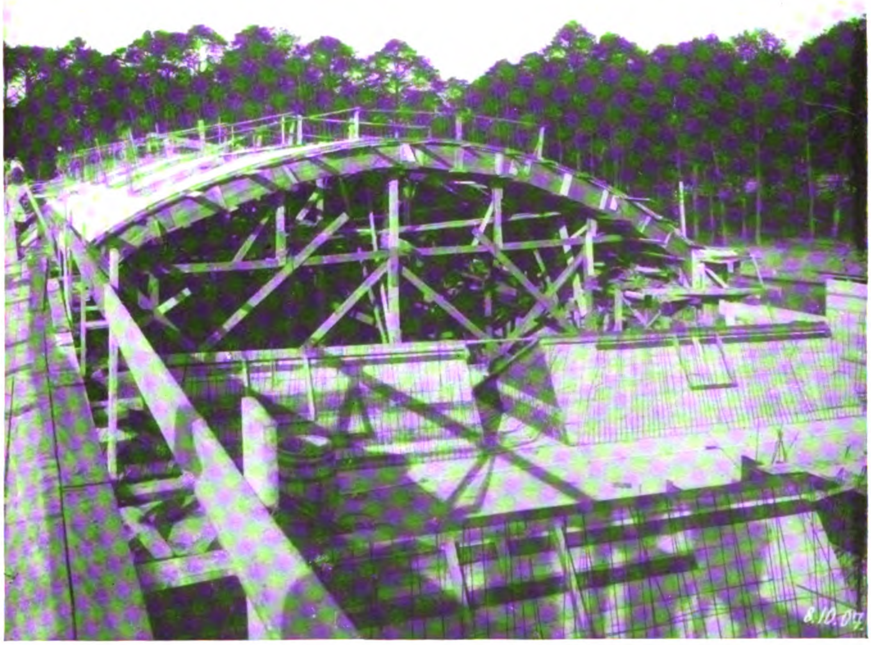
REINFORCED CONCRETE FOUNDRY. (General structural details.)

columns, roofs, etc., as well as of the skylights, are shown in the cross sections illustrated, and in photographs we have reproduced.

The foundry proper is located at the rear of the site, and consists principally of two galleries. These galleries are flanked by offices and stores. The roofs of the foundry galleries are vaulted, while those of the workshops are practically flat.

In the foundry two five-ton travelling cranes had to be provided for.

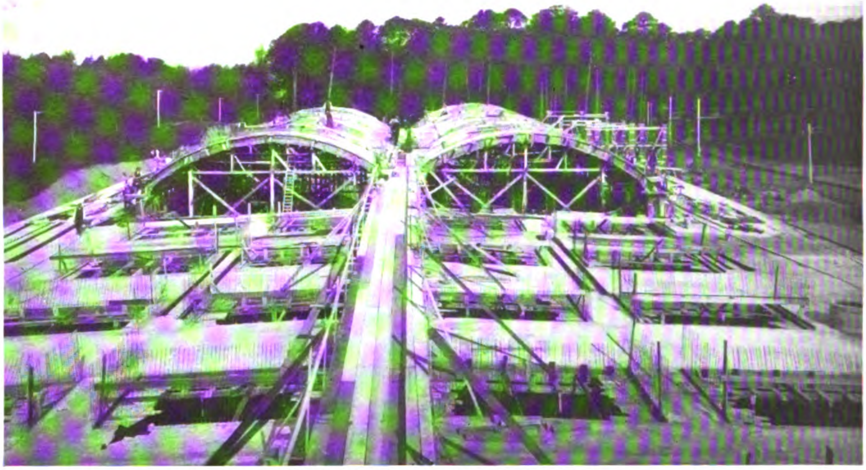
All floors, stairs, girders, columns, foundation, roofs, and sky-lights are of concrete reinforced with plain round steel rods.



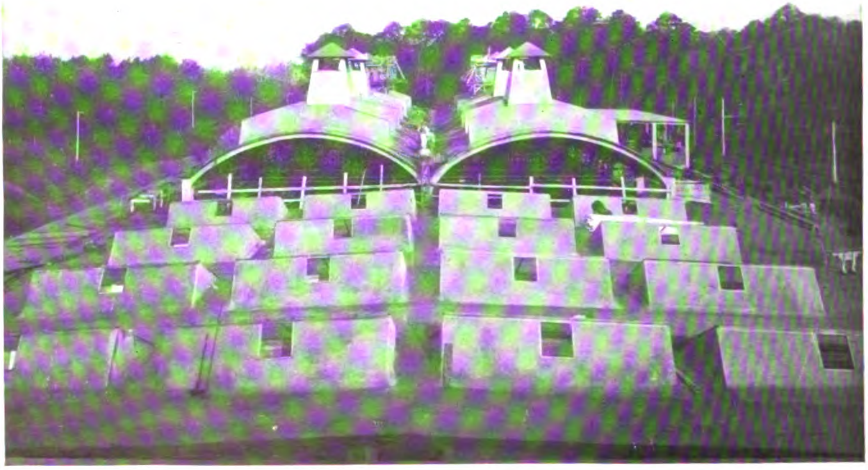
REINFORCED CONCRETE FOUNDRY.
(View of roof during construction, showing the reinforcing rods for skylights.)

In putting up the reinforced concrete work 1-in. pine was practically used throughout for forms, and the time limit for keeping the forms in position after concreting was 10 or 15 days. The forms were not wetted immediately preceding the laying of the concrete, as is frequently the practice. The concrete was machine-mixed, and consisted of mixtures of 1 and 6 for the foundations; 1 and 4 for the floors, roofs, etc., while a mixture of 1 and 2½ was used on the skylight work, the columns and girders; the aggregate was sandstone. The mixture was a fairly wet one throughout; the concrete was freely tamped.

The skylights and the flues which serve as ventilating shafts over the foundry proper are all constructed entirely of concrete, as is shown in the photographic reproductions. These openings are so planned that they take up about one-half of the area of the roof. The surfaces of these flues and skylights were reinforced with steel rods of about $\frac{3}{16}$ in. diameter, and were placed about 4 in. apart. The open side of the skylight was filled with wire glass.



(View of roof showing reinforcement.)

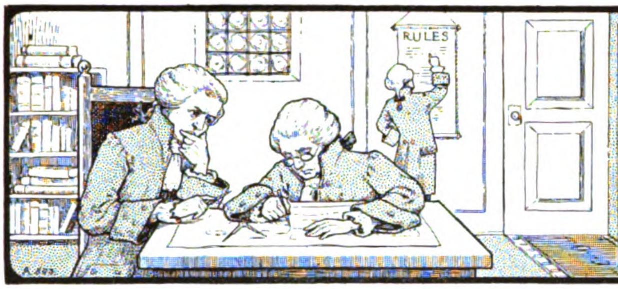


(View of roof showing skylights.)

REINFORCED CONCRETE FOUNDRY AT NONNENDAM.

The contractors were Messrs. Beton & Monierbau, Company, and the architect Mr. Carl Janisch.

For purposes of comparison of time and cost, it should be added that the men received 7d. to 9d. per hour, and worked 9 hours per day.



Concrete Block-Making in Great Britain.

PART IV.—*Concluded*.

By H. KEMPTON DYSON, C.E.

Although the United States, in particular, has been making great headway of late in the production and use of concrete blocks, both solid and hollow, progress in Great Britain has been somewhat slow in this direction, and we have thus pleasure in presenting some particulars as to the industry in this country in the form of a series of articles dealing with the subject both historically, as far as patents call for notice, and practically, as far as modern practice and experience are concerned.—ED

THE "Winget" concrete block-making machine has only recently been introduced on the English market by The (U.K.) Winget Concrete Machine Co., whose head office is at Star Buildings, Northumberland Street, Newcastle-on-Tyne. We illustrate in *Fig.* 43 the machine as operated for the release of the block after moulding. It belongs to the type of stationary machine, and it has a very large output, for the average number of hollow blocks, measuring 32 in. by 9 in. by 9 in., turned out over a period of three months, with only ordinary labourers employed, was recently found to be 300 per day. The whole operation of releasing the finished block—*i.e.*, removing the sides and ends of the mould and withdrawing the core—is done by the movement of one lever, while to close the mould box and replace the cores ready for filling with concrete is done by a reverse movement of the same lever. The type of machine illustrated is a side-face machine, but the principle is also applied to a face-down machine. The "Winget" machine may also be used for making solid blocks for the building of walls with a continuous cavity. In this case the machine makes two blocks at one operation, both of which may be ornamented if desired. The "Winget" machine therefore is a combination machine making practically all types of blocks, and has the advantage of making all sizes, including closers, that are necessary for British building construction from 32 in. by 4½ in. by 9 in. up to 32 in. by 16 in. by 9 in., and all special and moulded blocks within the latter size, including copings, plinths, strings, pier or column blocks, chimney or flue blocks, angle or quoin blocks. A number of cottages have been constructed with blocks made by this machine at Newcastle-on-Tyne, Harrogate, and Horden, Co. Durham.

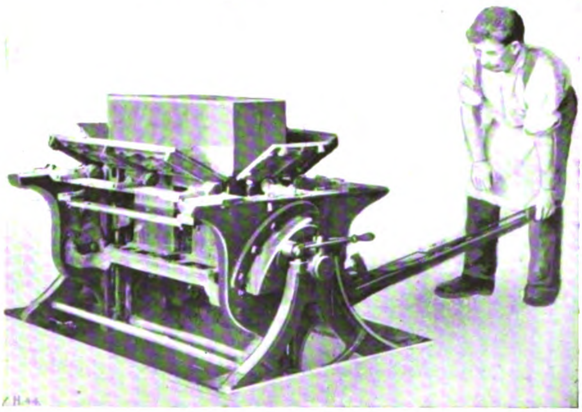


FIG. 43. THE "WINGET" CONCRETE BLOCK-MAKING MACHINE.

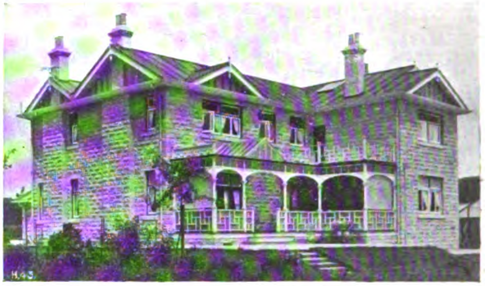


FIG. 45 HOUSE AT LITTLE HAMPDEN, GREAT MISSENDEN, BUCKS, BUILT OF HOLLOW CONCRETE BLOCKS.

The modern manufacture of concrete blocks is not solely carried on by machines. Moulds are also frequently used, for there are certain advantages in the way of economy and first cost, as also other reasons for which some authorities on concrete construction give moulds a certain preference.

The Swansea Stone Block and Machine Co., Ltd., are supplying a type of mould much favoured in America. This is known as the "Pettyjohn" machine, and is, indeed, an American invention. It is shown in *Fig.* 44. The following advantages are claimed for the "Pettyjohn" system of working:—(1) The blocks do not have to be carried away from the machine; (2) no heavy and expensive iron pallets are necessary; (3) the blocks are made on the floor instead of several feet above it, which is claimed to be easier for filling in and tamping; (4) no cogs, gears, springs or levers to get out of order; (5) changes can be made in the form of block, as the face plates are not a working part of the machine. A special large machine is made for moulding sills, copings and lintels. The weight of the standard machine is only 60 lbs., less than the weight of the block it makes. *Fig.* 45 shows a house which was built two years ago in the Chiltern Hills, known as "Alster," Little Hampden, Great Missenden, Bucks, the residence of Mr. Llewelyn B. Atkinson, A.M.I.C.E., M.I.E.E., to whom the author is indebted for the illustration. Mr. Atkinson says he employed local labour to make the blocks with a "Pettyjohn" machine, and then handed them to the contractor for the building. He says the house is a great success. *Fig.* 46 shows a sea wall that has been built at Cardigan of hollow concrete blocks made with the "Pettyjohn" machine. The Swansea Stone Block and Machine Co., Ltd., also makes another type of machine known as the "Invincible." This is a down-face machine, and it is claimed that this lays a richer and stronger face, although a finer surface can be formed of a block made by a side-face machine. In this the moulding is done in the same way as with the "Pettyjohn" machine, but the cores are laid horizontally in the machine, which is turned one-quarter way over, so that these cores may be withdrawn in a perpendicular direction. The machine is then released and set in place ready for the next block. A view of the "Invincible" machine is shown in *Fig.* 47.

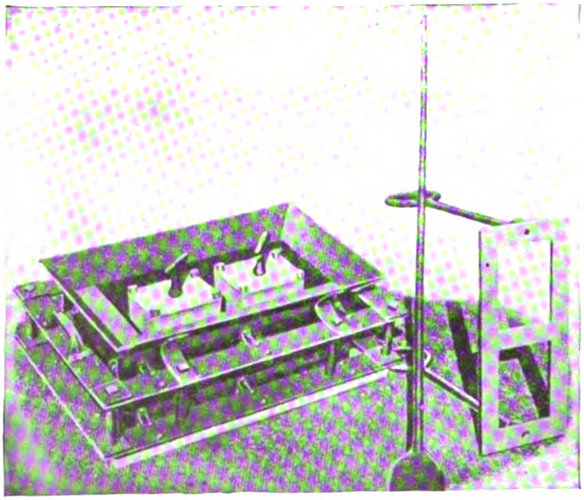


FIG. 44. THE "PETTYJOHN" CONCRETE HOLLOW BLOCK-MAKING MACHINE.

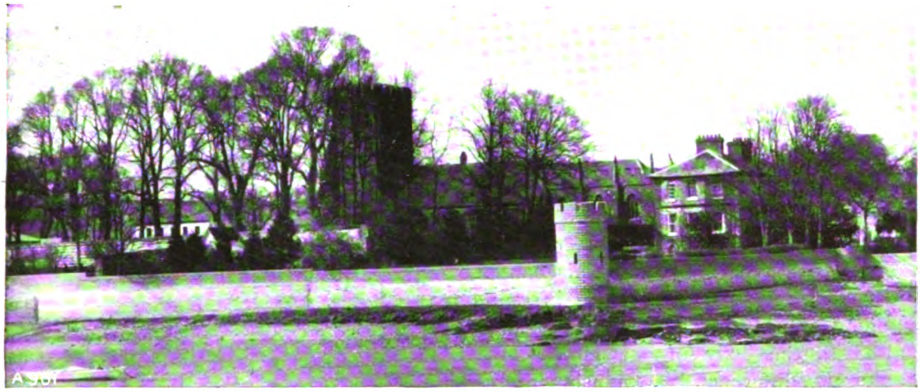


Fig. 46. Sea Wall at Cardigan, constructed with Concrete Blocks.

The firm also can supply a machine for making sand and cement bricks, which is illustrated in *Fig.* 48. The machines are of various sizes, making either 5, 10, 20 or 40 bricks at one operation. The quantities turned out with the machine are as follows :—

5 brick machines	...	one man	...	1,200 bricks per day	
5 do.	...	two men	...	2,500	do.
10 do.	...	one man	...	1,500	do.
10 do.	...	two men	...	3,500	do.
20 do.	...	two men	...	2,000	do.
20 do.	...	three men	...	6,000	do.
40 do.	...	two men	...	4,000	do.
40 do.	...	four men	...	8,000	do.
40 do.	...	six men	...	12,000	do.

The style of outer face which is generally favoured is known as "rock-faced," although "chiselled," and "ashlar" is also often adopted. The face plate is made by casting from an impression taken from an actually worked block of stone, so that the imitation of natural stone is very close, and with a little experience concrete blocks can be made which would almost deceive the majority of persons into the belief that they were stone, except that in a house erected with such blocks the uniformity and exact similarity of the blocks would show that they had been cast from the same mould. As to whether this exact imitation of natural stone is æsthetically legitimate is questionable, but if the surface is somewhat of the nature of roughly-dressed stone—*i.e.*, "rock-faced"—but does not exactly imitate worked stone, there is no æsthetic objection thereto. It certainly gives an appearance of strength, breaks up the surface, and as each block is exactly alike there is no deception as to the material; but it is possible to avoid even this and secure the broken surface and

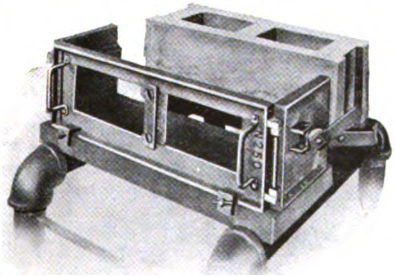


Fig. 47. The "Invincible" Concrete Hollow Block-making Machine.

feeling of strength by breaking up the surface with a pattern.

The concrete of the blocks can be coloured, either by the use of mineral oxides, if so desired, or the colour may be put upon the face by applying a first coating with the trowel in the form of mortar or stiff grout to the sides of the mould against the outer face. In the latter case the face is often made of a richer quality than the concrete behind. This can be made perfectly satisfactory, but in many cases the concrete face is not thoroughly united to the body of the block; and, again, the difference in expansion of the two qualities of concrete is sufficient to cause trouble in flaking Furthermore, when the blocks become wet a mottled appearance may be developed on the wall surface.

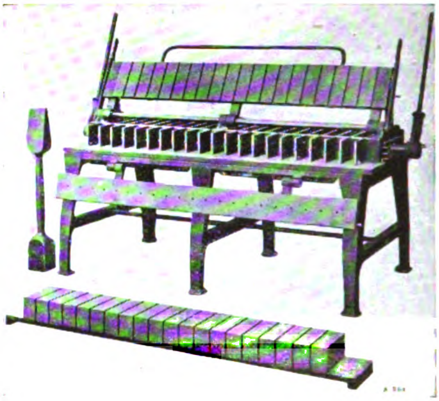


FIG. 48. CONCRETE BRICK-MAKING MACHINE.

SOME FINAL HINTS.

A warning needs to be given to inexperienced users of concrete block machines, for there have been many failures that have brought concrete blocks into undeserved disfavour in certain quarters. Very often the materials used are unsuitable; dirty and porous aggregates, very loamy sand, insufficient cement, and bad mixing are fruitful causes of failure, but the chief one is the use of too dry a mixture with the desire to save time in moulding and handling. The concrete should be just wet enough to show moisture on the top when well rammed in the moulds. A really wet mixture cannot conveniently be used as a rule, though it makes a much denser concrete. In the manufacture of artificial stone, shaking tables for rocking the moulds when wet mixtures are used, so as to remove bubbles of air and secure an even face, were introduced some years ago, but they had a tendency to shake the heavier aggregate to one end and wash the cement to the top.

An improved form of shaking table has been recently introduced by the Improved Construction Co., Ltd., Westminster, which has many advantages. This oscillates in all directions at once, and does not cause the aggregate to move sideways but merely vertically, thus wedging the particles together so as to form a very compact concrete that can be removed from the moulds within about an hour. This gives the advantages of wet moulding while enabling the blocks to be removed from the moulds very soon after they are made, so saving the expense of a great quantity of moulds.

A similar principle of shaking the concrete was applied some time ago by Mr. Richard Bowen, of the Monocrete Construction Company, of Cheltenham, in a machine for moulding concrete blocks, with this difference, that the concrete was not only shaken, but was at the same time pressed in the mould. The manner in which the blocks were moulded was for the plunger to work within the mould box, the pressure being applied gradually, while the mould box was sharply shaken by blows being struck against it as the plunger descended. Blocks of very great density and strength were thus obtained.

Dry-moulded blocks, and also wet-moulded ones to a lesser extent, require well curing to give good results. After the first twenty-four hours the blocks should be thoroughly wetted with a hose for ten minutes every morning and evening for a period of ten days.

ADDENDA.—The author has been informed by Mr. W. F. F. Bevis, of Gravesend, that he was the patentee of the L-shaped block made by the Bowstone Co., and referred to in our September issue, and that the concrete blocks used in the construction of Torry Hill House, near Lenham, Kent, in 1856, referred to on page 294 of the same issue, were hollow. Thus that building appears to be the earliest known example of a hollow concrete block building.

CONCRETE-MAKING MACHINERY.

PART III.

(*Concluded.*)

By DR. JOHN S. OWENS,
A.M.Inst.C.E., F.R.G.S.

The appliances available for concrete-making or mixing are not fully known, and we are thus publishing these articles dealing with this important subject.—ED.

Owens Gravity Mixer.—As the name implies, all gravity mixers work without the aid of power, and consist broadly of some means whereby the materials in falling through a certain height have the ingredients composing them thoroughly incorporated together.

This mixer consists of a steel shoot about 7 ft. long, containing three sinuous mild steel bars extending in one length from the top to the bottom of the mixer (see *Fig.* 18). These bars are fixed rigidly at the top and are held loosely at the bottom by means of a ½-in. pin, which passes through them. In addition there are eight large and six small baffle plates fixed to the sides of the shoot. An inspection door, seen open in the figure, is provided to facilitate cleaning.

The water supply pipe is fixed behind the lower edge of the top baffle plate, and is perforated both back and front with a row of ⅛-in. holes, and provided with a brass cock to regulate the supply. By this arrangement the whole of the plates and bars receive a spray of water, and a wet surface throughout the mixer results to meet the falling aggregate.

The action of this apparatus is to cause an alternate splitting up of the materials thrown in into pairs of columns, which are again thrown together, this action being repeated eight times in falling the length of the mixer.

The output of such machines as this really depends upon the amount which two men can shovel into the hopper.

The standard size of this machine is 7 ft. 1½ in. long over all, but different lengths are made to suit various requirements.

The Pansy Mixer.—This is a machine bearing some resemblance to the Mason Pan Mixer. The place of the pan is taken by a revolving circular, or rather annular, vessel (see *Fig.* 19). This vessel has exterior and interior sides, between which the material

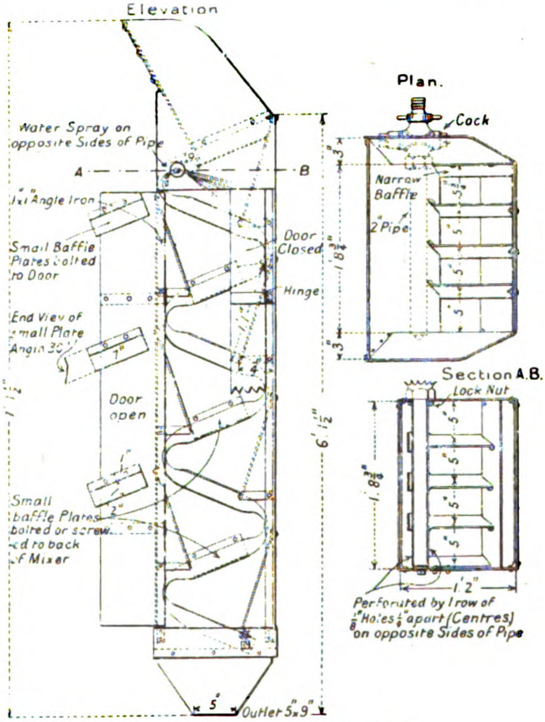

Elevation
Water Spray on opposite Sides of Pipe
A
B
1"x1" Angle Iron
Small Baffle Plates bolted to Door
End View of small Plate Angle 30°
7"
Door open
1"
2"
Small baffle Plates bolted or screwed to back of Mixer
Door Closed
Hinge
4"
6' 1½"
7' 1½"
5"
Outlet 5"x9"
Plan.
Cock
Narrow Baffle
2" Pipe
3"
1'8¾"
5½"
5"
Section A.B.
Lock Nut
1'8¾"
1'2"
Perforated by 1 row of ⅛" Holes ½" apart (Centres) on opposite Sides of Pipe

FIG. 18. OWENS GRAVITY MIXER.

is mixed. It runs on a ball-bearing cast-steel base, and is driven by a pinion connected with a geared rim on the outer side. Through the centre of this annular vessel is a perpendicular shaft, to which are attached angle iron frames, to which again ploughs are fixed. These ploughs are adjustable, and can be raised or lowered at will, one set of ploughs being right hand, extending from the inner to the outer circle, so that every part of the material is dealt with and turned over; the other set is left hand, and turns the material in the reverse direction.

The materials are gauged in the ordinary way on a platform above the machine, and tipped directly from it into the machine. The ploughs are raised above the materials while feeding, they are levelled with a scraper, which is then withdrawn and the ploughs lowered again into the mixing vessel. A dry mixing may then be given and the water added. As soon as the concrete is thoroughly mixed the ploughs are raised, the scraper lowered, and by means of trap doors in the bottom which are opened and closed by catches, the mixed concrete is forced through the bottom of the vessel always at the same place into a barrow, skip, or other receptacle. The doors then close themselves automatically by means of the closing catch, and as soon as discharge is complete the mixer is ready for another charge. All operations are carried out while the machine is running.

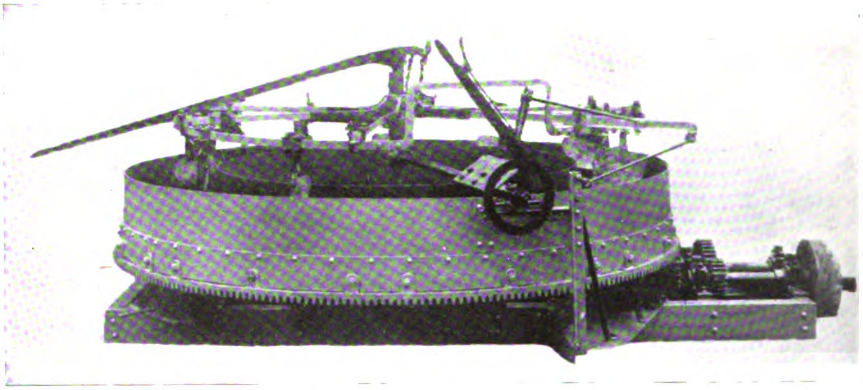


FIG. 19. "PANSY" CONCRETE MIXER.

One advantage which this machine possesses over closed mixers is that the whole process is visible, and may therefore be controlled with greater certainty than if the concrete is shut up from view during the mixing process.

The machine is made in two sizes: No. 1 has a capacity per batch of ⅓ cub. yd., and requires 4 h.p. to drive. No. 2 is of ½ yd. capacity per batch, and requires 5 h.p. to drive. I am unable to give the output of this machine, as up to the time of writing it has only been used experimentally by the makers.

The Taylor Mixer.—This is a batch mixer of similar type to the "Smith." It has a double conical revolving drum, fixed in a tilting frame for the purpose of discharging. An older form of the same machine did not tilt to discharge, but had a series of doors actuated by levers fixed round the drum through which the mixed concrete could be emptied. An elevator of the chain and bucket type is sometimes fitted to feed the ballast into a hopper, whence it is delivered to the drum.

The makers state that a half-yard machine will produce 10 yds. of concrete per hour, and if fitted with friction hoist and crane can produce 15 yds. per hour. The one-yard mixer is claimed to produce in ordinary working 22 yds. of the best concrete per hour, at a cost for labour of about 4d. to 5d. per yd.

The drum runs at 12 revolutions per minute, and can be fed and discharged while running.

A half-yard machine in use on the Tynemouth Corporation Waterworks turned out for the first month of use an average of 21·5 mixings per hour, and for a period of about 10 days 27 mixings per hour. The gang employed for one mixer was 1 foreman, 1 man attending to machine, 6 men wheeling and tipping, 1 man on cement, 1 man on stone tip, and 2 men getting the trolleys with loaded skips from the mixer to the steam cranes.

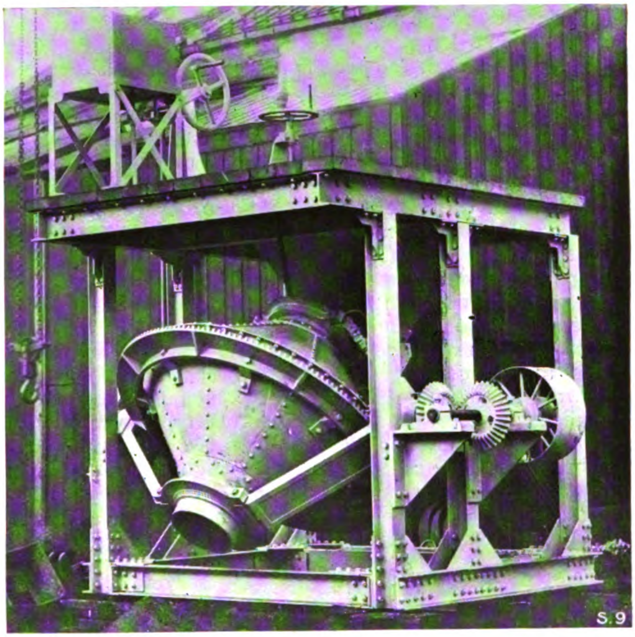


Fig. 20. Taylor Mixer.

The Trump Mixer.—This was illustrated in *Fig.* 2 of the previous articles. It is a continuous mixer, and the special measuring device has been described already. Mixing is effected in a trough having a spindle fitted with knives revolving in it, which, owing to the helical disposition of the knives, causes the materials to travel towards one end. *Fig.* 21 shows a large "Trump" machine fitted with chain and bucket elevators to deliver the materials into the revolving cylinders. It does not call for further description, as the measuring mechanism is the point of interest in the machine.

The (U.K.) Winget Concrete Machinery Co.'s "Express" Mixer. (*Fig.* 22).—This machine, which is somewhat of the pan mill type, has a stationary pan, and revolving in it a series of plough-shaped beaters and rakes attached to arms which project from a central capstan head. It is claimed that the particular shape of beater and rake used have special mixing properties.

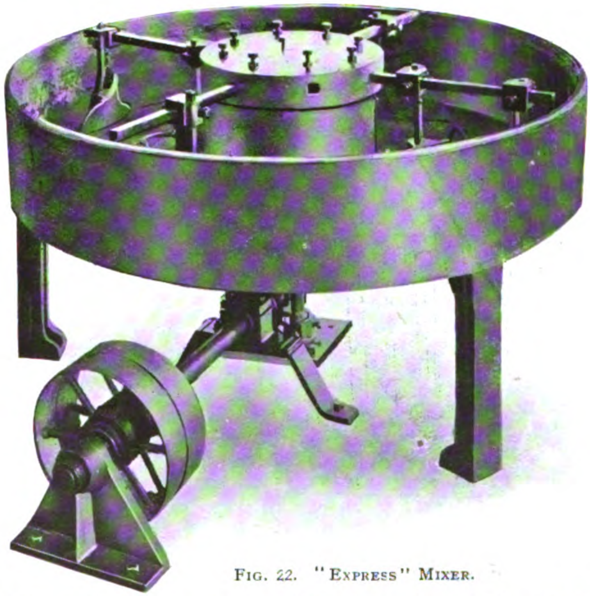


Fig. 22. "Express" Mixer.

Fig. 22 sufficiently explains the method of working. There are two discharge doors in the bottom of the pan, designed to be easily withdrawn and replaced; and through these a No. 1 size pan can be emptied in 15 seconds, according to information kindly supplied by the makers. The mixer is fed and discharged while running.

These mixers are supplied for fixing permanently, as in *Fig.* 22, or with a rolled steel frame, wheels and axles, if desired. The No. 1 size has a 6 ft. 6 in. pan, 1 ft. 4 in. deep, and is intended for materials up to ¾ in. gauge; it takes a batch of 6 cu. ft., which, I am informed, it mixes in one minute, thus giving an output of about 13 yds. per hour; it requires five i.h.p. to drive. The No. 2 has a 9 ft. pan, and is intended for materials up to 2½ in. gauge; it takes a 1 yd. batch, which it is stated to mix in three minutes, giving an output of 20 yds. cu. per hour.

In conclusion, I would point out that concrete is one of the most difficult materials to handle effectively by machinery; not only is it composed of hard, gritty particles which tend to find their way into the working parts of the machine, but also the setting property of the cement adds another difficulty. In choosing a machine the output as obtained from some thoroughly reliable and authenticated source is of great importance. The power required to drive should be carefully ascertained. But perhaps the most important point of all to look into is the construction of the machine; it is useless to get a light, flimsy machine which will break down, wear, or rust out in a few months. Such a mixer looks just as well in the maker's yard as a solidly-built, well-constructed one, but I know of no machine in which bad workmanship or faulty design or material so soon begins to show itself as in a concrete mixer. And one final word as to the output. This is affected by not only the extraneous circumstances unconnected with the machine itself before referred to, but also the quality of the concrete turned out and the *amount* of mixing it has received. For it must be remembered that the completion of the mixing process is usually determined in a very rough-and-ready way, usually by a mere inspection; hence there is great variation in the time which is considered sufficient to mix, and consequently in the output of a machine when worked under different circumstances and different control.

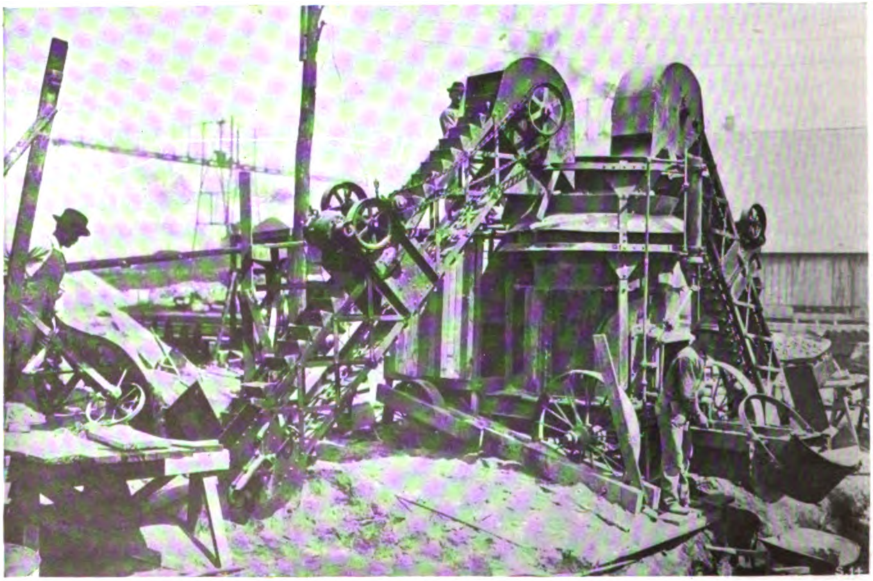
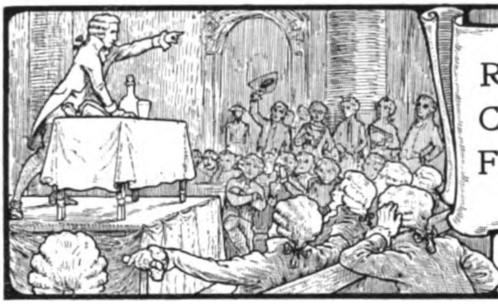


Fig. 21. Trump Mixer.



RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.

THE CONCRETE INSTITUTE.

It is our intention to present the Papers and Discussions of the Concrete Institute in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

SINCE our previous issue the first two meetings of the Concrete Institute have been held, and the proceedings certainly call for considerable attention in these columns.

The selection of the Royal United Service Institution for the meetings is a happy one, not only having regard to its excellent accommodation, but also for the distinguished character of the building and its accessibility both from that great centre of civil engineering, Westminster, as also from the public offices.

An effort seems to have been made that the business should be carried through in a plain, straightforward manner, without any of the superfluous laudation and complimenting which has become rather an unnecessary feature in some of the older societies. There is also a ten minutes' time limit for speakers in the discussion, which materially adds to the brightness of the proceedings.

The first meeting was presided over by Sir Henry Tanner, I.S.O., F.R.I.B.A., Principal Architect H.M. Office of Works, a Vice-President of the Institute, and at the second meeting the chair was occupied by Mr. Edwin O. Sachs, F.R.S.Ed. (Chairman of the Executive). Both meetings were well attended, some two hundred members and friends being present at the November meeting, no small number for a young institution, and over a hundred at the second meeting, which was an afternoon meeting.

THE PAPERS.

A curious feature of the two meetings was that the first two papers should have been prepared by those well-known collaborators, Mr. Marsh, M.Inst.C.E., and Mr Dunn, F.R.I.B.A.

As to Mr. Marsh's paper it took much the form of a summary, and fulfilled its object by raising a very excellent discussion of exceptional vivacity.

Mr. Dunn's paper, it should be mentioned, met with general approval, and covered the ground intended in a manner which did both author and Institute credit, and if in this particular case the discussion was not quite so vivacious, it was certainly eminently useful.

A pleasant feature of the meetings was the announcement regarding the roll of members and subscribers. At the first meeting the lists had touched 300, while at the second meeting they had reached 400.

We further understand that some of the standing committees have started work, and it is an open secret that the Science Standing Committee will have its hands extraordinarily full. The Parliamentary Committee, we understand, had an important meeting in December, when Mr. Riley, F.R.I.B.A., the superintending architect to the London County Council, unofficially attended at the invitation of the Executive and explained the bearings of certain proposed enactments. Altogether the workers on the Institute appear to be in for a busy time.

The annual subscription for new members is, we understand, to be raised when the number reaches 500. Particulars as to membership can be obtained from the Honorary Secretary, Mr. A. E. Collins, M.Inst.C.E., at the offices of the Institute, 1 Waterloo Place, London, S.W.

THE FIRST MEETING.

THE COMPOSITION AND USES OF PLAIN AND REINFORCED CONCRETE.

PAPER by CHAS. F. MARSH, M.Inst.C.E.

The Chairman, Sir Henry Tanner, I.S.O., F.R.I.B.A., Vice-President, having opened the proceedings, the following remarks were made :—

MR. EDWIN O. SACHS, F.R.S.Ed., Chairman of the Executive.

The Concrete Institute.—The Institute, which was started with 100 founders, already had a list of members exceeding 300, of whom alone over a hundred were members of the Institution of Civil Engineers, and no less than 25 hailed from the Colonies.

The Institute had as its President the Earl of Plymouth, C.B., until lately First Commissioner of Works, and as its Vice-Presidents, besides Sir Henry Tanner, Sir Douglas Fox, Kt., J.P. (Past President of the Institution of Civil Engineers), Sir William Mather, Kt., J.P., LL.D., M.Inst.C.E. etc., and Sir William Preece, K.C.B., J.P., F.R.S., LL.D. (Past President of the Institution of Civil Engineers).

The objects of the Institute might be summarised as follows :—

(*a*) To advance the knowledge of concrete and reinforced concrete, and direct attention to the uses to which these materials can be best applied.

(*b*) To afford the means of communication between persons engaged in the design, supervision, and execution of works in which concrete and reinforced concrete are employed (excluding all questions connected with wages and trade regulation).

(*c*) To arrange periodical meetings for the purpose of discussing practical and scientific subjects bearing upon the application of concrete and reinforced concrete, and to conduct such investigations and to issue such publications as may be deemed desirable.

Mr. Sachs then went on to say that the great necessity for this Institute might, perhaps, best be gauged from the fact that the number of technical questions and suggestions made to its Council immediately upon formation had been simply enormous, and of such a scope as to practically require enquiry, research and investigation for years. It was to be hoped, Mr. Sachs added, that the British public authorities concerned will find it advisable to contribute in some way towards the expense of the research work necessary. In America the United States Government had already contributed £25,000 for research work in this direction, while the German authorities had contributed £20,000 towards research in reinforced concrete alone.

There could be no doubt that the advance made in the application of concrete and reinforced concrete had been most extraordinary during the last few years, and that, if the last half of the past century could have been termed the " Steel Age," there was no doubt that the first half of the present century would be known as the " Concrete Age."

In every direction, be it above or below ground, and if below, be it below water or in the depth of mines, concrete was being applied to most important work, but not only was it being applied to works of an engineering or structural character, but also to such minor uses as pipes, drains, fence posts, standards, vessels to hold water, and in fact to many of those purposes in which wood and earthenware had previously been employed.

SIR HENRY TANNER, I.S.O., F.R.I.B.A., Vice-President.

The Concrete Institute.—The Chairman remarked that no one would have predicted that concrete could have grown in importance and general interest so as to demand an Institute to itself, and the First General Meeting of the Institute should be regarded as one of some historical interest and as indicating the advancing changes in building and engineering construction, while the statistics which Mr. Sachs had communicated to the meeting should give some idea of the appreciation accorded to it.

The details in connection with the uses of concrete were numerous, and had engaged a large amount of attention in other countries as well as in this, but although Great Britain was to some extent the last in the field, he was confident that the constructors of this country would not be behind in the practice of concrete construction, reinforced and otherwise, and it might be assumed that the Institute would be the means of adding to the knowledge of overcoming difficulties and affording facilities for interchange of views and discussion. It was his opinion that the members would look forward to the Institute taking an important place among other technical bodies.

The Chairman then asked Mr. Marsh to read his paper on ' The Composition and Uses of Plain and Reinforced Concrete."

CHARLES F. MARSH, M.Inst.C.E., the Reader of the Paper.

Portland Cement.—After a few introductory remarks, Mr. Marsh said that the so-called natural cements were very uneven in their composition, since the chemical constituents are not carefully proportioned as is the case with Portland cement. Natural cements were, it is to be feared, sometimes placed on the market as Portland cement, and care should be taken, when Portland cement was specified, to ensure that the proper material was supplied.

The manufacture of Portland cement had been very greatly improved within recent years. The materials were scientifically proportioned and all the processes of manufacture were carefully supervised. The improvement had been largely brought about by the gradual development of a thorough system of testing, but it was also due in a very great measure to the scientific study of the material by the manufacturers, most of whom have trained chemists on their staffs. It was, in fact, owing to the intelligent co-operation of engineers and manufacturers that the artificial Portland cement of to-day was an infinitely more reliable material than it was formerly.

Cement has within recent years been considerably improved by the finer grinding obtained by the introduction of tube mills, and at the present day it is quite usual to obtain a cement which will leave less than 15 per cent. residue on a 180 sieve. Generally speaking, the finer the grinding, or rather the greater the percentage of impalpable powder, the stronger will be the mortar or concrete made from a cement. This increase in the strength of mortars and concrete due to the fineness of the cement will be shown by the behaviour of the sand briquettes, the tensile resistance of which increases with the fineness of the cement used.

Mixing of Concrete.—In regard to the mixing of concrete, Mr. Marsh lodged a protest against the not unusual practice of defining the proportions as 1 to 4, 1 to 6, etc., which gave no indication of the relative quantities of sand and stone. Such a definition was only permissible when using a ballast or unscreened broken stone, and in such a case it should be clearly specified that a proper quantity of sand should always be maintained in the aggregate, either by the addition of further sand or the screening out of a surplus. Definite proportions of cement, sand and stone should always be adopted for the best classes of concrete. It was probable that before long the old method of proportioning by volumes of cement, sand and stone would be superseded by the proportioning by weight of cement to volumes of sand and stone. This appeared to be the rational method, since the cement was sold by weight, and it therefore seemed to be only reasonable that it should be proportioned by weight. It was impossible to always obtain the same amount of cement in gauge boxes, as the method of filling had a considerable effect on the quantity. The contractor carrying out any works had a much better control on the amount of cement used when it was proportioned by weight, while the engineer or architect was sure of obtaining the proper quantity.

As a rule, machine mixing gave a more even concrete than hand mixing if "batch" mixers were used.

Concrete Aggregates.—The nature of the aggregates in concrete depended in a great measure on the locality, but it was an undoubted fact that, all other things being equal, the harder the aggregate the better the concrete. For some purposes, such as for reinforced concrete, which may be subjected to fire, certain aggregates should be avoided. Crushed limestone, for instance, would disintegrate when subjected to heat, and should not be used for fire-resisting structures. It was better to avoid the use of flints, if possible, when fire resistance is a desideratum, and if they are used it was advisable to break them, since they will break on the lines of cleavage, and the broken pieces will consequently have less tendency to fly.

Consistency of Concrete.—The question of the proper consistency of concrete had received a good deal of attention since reinforced concrete became a recognised structural material. In the early years of the use of this material very dry concretes were almost universally employed, but at the present time it had become the almost universal practice to use a somewhat wet mixture, and some constructors favoured a quite sloppy consistency. It appears that, as usual, the mean was the best, as although a dry mixture, very thoroughly rammed, gave the strongest concrete, the ramming is likely to be shirked, and in any case the steel of reinforced concrete was not so well protected by a dry as by a moderately wet concrete, which required only moderate ramming.

Waterproofing Concrete.—The proper waterproofing of concrete structures was becoming a question of great importance. The extended use of concrete block and reinforced concrete construction forced us to consider seriously the provisions which might advantageously be taken to secure concrete from the penetration of water. Many materials, both natural and manufactured, had been employed as ingredients in the concrete with more or less success, and under small heads were undoubtedly beneficial so long as the concrete did not crack, but as soon as a crack existed it was evident that such ingredients were useless as preventatives to the penetration of moisture.

Protection of Steel.—A doubt still remained in some minds as to the adequate protection of the steel against oxidation in reinforced concrete structures. Personally, the lecturer was convinced that provided the concrete was of a dense nature, such as was always used for reinforced concrete, was not mixed too dry, and was well worked around the reinforcements, there need be no fear that the steel would become oxidised.

Nature of Reinforcing Metal.—The advantage or otherwise of high carbon steel as a reinforcement was a question which might be expected to raise some discussion; personally, he was of the opinion that when employed in members subjected to bending the small advantage gained by its use when relatively small unit moments of resistance were required was counterbalanced by the probability that the highest stress allowed in the steel will cause the concrete on the tensile side to crack. With the higher percentages of reinforcement, when the compressive resistance of the concrete became the ruling factor, there could be no advantage in the use of high carbon steel.

For compression members of the ordinary construction even mild steel could not be stressed to its allowed limit; for such members, therefore, there could be no advantage in the use of high carbon steel. For hooped members, if the allowable compressive stress in the concrete was higher than about 1.000 lbs. per sq. in., it was advisable to use high carbon steel for the longitudinal reinforcements, and the employment of high carbon steel for the bindings was always advisable. For the purpose of resisting temperature stresses there was an advantage in the use of high carbon steel, as its greater resistance would enable it to offer more assistance to the concrete.

Form of Reinforcing Bars.—The advantage of the use of deformed bars was another subject which would doubtless raise discussion. There was no doubt that deformed bars offered more resistance than plain bars against sliding through the concrete, but the real question appeared to be whether plain bars offered sufficient resistance, as if such was the case there could be no real advantage in the employment of deformed bars, especially if they were more costly.

Mesh Reinforcements.—The Institute might well carry out some experiments to ascertain definitely the relative merits of various mesh reinforcements, and of plain rods either loose or tied at the intersections for reinforcing slabs. Tests might also be made to ascertain what increase of resistance is effected by placing the mesh reinforcements diamond-wise, so that they may have a tendency to close up under tensile stresses.

Test Loading.—The Institute might express its opinion as to the percentage of the superimposed loading which should be used in applying test loads to a finished structure, the position of its application on various types of floors, etc., and the period which should be allowed to elapse before a structure was tested.

Architectural Rendering.—The subject of concrete surfaces and the architectural treatment of concrete structures generally was one which must be of extreme importance before long, and this Institute will doubtless render valuable aid in adapting this material to architectural uses.

Design of Reinforced Concrete.—It could not be doubted that before very long engineers and architects generally would take up the design of the structures they wish to erect in reinforced concrete, or would entrust the design to specialists other than the firms constructing in the various "systems."

It was to be hoped that these firms would adapt themselves to the new conditions and become specialists in a broader sense than they were at the present time. They occupied a very advantageous position with regard to the designing and carrying out of reinforced concrete works, having considerable experience of the practical methods of construction. With reinforced concrete, perhaps to a greater extent than any other structural material, the practical considerations of construction influenced the scientific and economical design.

It could not reasonably be expected that reinforced concrete would remain a multitude of various more or less rational systems relying on more or less valid patents. If such were to be the case it was to be feared that its employment would be seriously affected.

This method of construction was not, and could not be, split up into defined systems, it must be adapted to the requirements of each case in the best manner possible; and while all honour was due to those men who, as proprietors of the various systems, had undoubtedly borne the labour and heat of the day, it was to be sincerely hoped that they would not try and hinder the advancement of this very excellent method of construction by petty disputes, but would come to take a broad view of the whole question. The lecturer was sure that it would be to the great advantage of all concerned when the various systems were merged into one, and reinforced concrete took its proper place as a method of construction which by reason of its great adaptability could be employed for a vast number of different types of construction. It was certain that there would be no lack of work for specialists if this broader view were taken and they undertook the design and construction of works in reinforced concrete without restricting themselves to their one particular system.

Standardisation of Symbols.—This Institute will probably enquire into the standardisation of the symbols used for the calculations of reinforced concrete structures. It was unfortunate that so many systems of symbols should be used by various authors, and the lecturer was afraid that some might consider that he was one of the chief sinners in this respect. With such a subject as reinforced concrete the matter of proper symbols was one which required very careful consideration. There were so many different symbols required that the available alphabets were hardly sufficient for the purpose, and when trying to deal with the calculations in a complete manner one sometimes wished the Chinese alphabet were universally understood, as it might come in very handy when the Latin and Greek letters were all used up.

The Chairman called upon Mr. Wentworth-Shields to open the discussion.

MR. WENTWORTH-SHIELDS, M.Inst.C.E.

Advantages of Lime.—Mr. Shields stated that English engineers have grown rather scornfu of lime now that such excellent Portland cement is available, but when in charge of one of the big barrages across the Nile, the work was almost wholly constructed of what might be called a rubble concrete, formed of lime and what was known there as "homra," which was practically bricks ground up to a very fine powder bv mechanical disintegrators, and the work seemed to him excellent. He was unfortunately prevented from carrying out some definite experiments on the actua strength of the work. He had the opportunity of seeing some work which had been built in precisely the same way in the Assiout barrage some 5 or 6 years previously, and found it hard and good. In the heart of the work the quality of the mortar was uniform and excellent.

Aggregates.—The speaker considered that it was more generally recognised now than a few years ago the necessity of the stones in a really good cement being of all sorts and sizes, as also the sand. In that sense a natural gravel seemed to score a point over the artificial mixture of broken stone and sand, because in a natural gravel concrete, when it had got the different assortment of sizes, one got coarse and fine sand, large and small stones, and thus the best possible mixture.

The proportions of stones and sand must, however, depend on the sort of mixture wanted for strong concrete or dense concrete. It might often happen, for instance, that a concrete which was made up entirely of stones and Portland cement would be weakened considerably by the addition of sand, although it would become denser.

Oxidation of Steel.—The speaker said he had had some opportunity of seeing what the life of steel is likely to be, and said that, on the whole, it is satisfactory, although there are situations in which oxidation does take place. The existence of 1½ in. of even the very best concrete overlying steel will not absolutely protect it from oxidation. It had been found that although certain buildings stand extremely well, there are some structures, notably some of the reinforced concrete jetties, in which oxidation had taken place, and the cause was not quite clear, that where oxidation had taken place, it was not universal and not absolutely due to any want of quality in the concrete. The concrete had been excellent, but apparently a cause that had something to do with it was excessive vibration caused by traffic passing over the quay. Another cause might be excessive deformation due to the beams being rather shallow, but all causes might be overcome.

MR. MEIK, M.Inst.C.E.

Cement.—Mr. Meik stated his concurrence with the remarks made regarding the occasional unreliability in the setting time of cement made in the rotary machines, but considered that when set it made excellent concrete. He considered that measurement by cubic feet should be adhered to as regards the sand and the stone, and the weight as regards the cement.

Proportions.—The speaker continued that there was no doubt that in making the concrete a great deal of strength was lost by not proportioning our stone and sand and cement properly. If a mixture of 1 to 6 was taken in ordinary work, that would be 1 cu. ft. of cement to 2 cu. ft. of sand, and 4 cu. ft. of broken stone. In the sand alone the voids would probably amount to 50 per cent. If that cement and sand is made into a mortar, you would get for the 1 cu. ft. of cement 2 cu. ft. of sand and only 2 cu. ft. of mortar. In the 4 cu. ft. of broken stone would probably be 50 per cent. of voids, and the whole of the mortar, mixed with the broken stone, would fill up the voids as it ought to do. The result would be a concrete amounting to 4 cu. ft.—*i.e.*, the whole of the mortar would have disappeared into the voids of the stone.

Impermeability.—Mr. Meik gave it as his opinion that the stone, in certain instances quoted by Mr. Shields, was not properly graded. He considered that concrete made with gravel was more permeable than that made with broken granite properly graded.

Corrosion.—The foregoing remarks also applied very closely to the subject of corrosion.

MR. BLOUNT, F.I.C.

Cement.—Mr. Blount admitted that the methods of controlling the setting time were at present rather imperfect, especially with what was called rotatory cement. It was a difficult matter to handle, and was made more difficult by the fact that people generalised too easily, because a case might come when a cement can be controlled by water or with the addition of calcium sulphate, or in some other well-known manner, and they deduced from that that all difficult controllable cements might be dealt with in the same way. On the contrary, each case must be studied on its merits.

Mr. Blount stated that he could not help thinking that concrete would be better made if the cement were weighed and if the voids in that concrete were measured.

Putting a general question as to the amount of voids existing in well-made 6 to 1 concrete, a member replied from 30 to 53 per cent. Mr. Blount then stated that the very best 6 to 1 concrete contained about 30 per cent. of voids.

MR. H. K. G. BAMBER, F.C.S.

Portland Cement or Lime Concrete.—Mr. Bamber asked Mr. Marsh if he could give any reason for throwing doubt as to the desirability, in bulk concrete works on land, of using lime instead of cement concrete. It seemed to him that Portland cement concrete must have shown its value as compared with lime, and that there could be no possible doubt that Portland cement was the correct thing to use. But Mr. Marsh, and perhaps Mr. Shields, had referred to some concrete work made with lime some 5 or 6 years ago. He imagined that it might have been done purely from the economical point of view. At that time the relative value of lime as compared with Portland cement was very considerable, he thought, considering the average market value of the very best possible cement to-day, that no engineer would feel that he would get any economy even by using lime in preference to cement, and he considered that, unless Mr. Marsh could give some other good reason, no engineer would prefer lime to cement if he could get his cement concrete made as cheaply as he could the concrete made with lime.

Slag Cement.—Mr. Bamber stated that the lecturer's remarks referred to the old method of making slag cement, mixing lime with slag, and also to the undesirability of using any cement with slag for ferro-concrete work. The speaker referred to a short report he had read on concrete by Professor Rudolph Dyckerhoff, who pointed out that over a series of 3 or 4 years he had been able to prove conclusively that cements containing any proportion of slag do show a continual and a gradual expansion as compared with pure Portland cements, and he agreed with Mr. Marsh that slag Portland cements or any cement containing slag should not be used in reinforced concrete work where iron was forming part of the material.

Setting Time of Portland Cement.—The speaker stated that Mr. Blount had referred to his personal research in the setting time of rotary cement, but he now considered that to a very large extent the difficulties had been overcome. He stated that he would like to impress upon Mr. Meik or his contractors that when they wanted a slow setting cement to be very careful that they did not buy a quick one. It followed that a quick setting cement was only useful in very special cases, and to attempt to use it for heavy mass work was a great mistake. Cement was a very different thing from steel or any other such material, and there never will be a process discovered which will regulate the setting time of any Portland cement and keep it at that particular setting time under varying conditions of atmosphere or temperature.

Fineness of Grinding.—The speaker referred to the lecturer's remarks as to the improvement in the fineness of grinding in Portland cement, and particularly to the British Standard Specification which standardised cement at 18 per cent. residue on a 180 sieve. He stated that an enormous quantity of cement was made at the present time, not 18 per cent. on 180, but 5 per cent. on 180, and with that cement he had not the slightest doubt Mr. Meik would get the enormous crushing strain such as he spoke of, as compared with the crushing strain he would obtain if he used a more coarsely ground cement.

MR. H. H. STATHAM,. F.R.I.B.A.

Mr. Statham said that although he was more of an artist than an engineer he was much interested in the subject of concrete.

Aggregates.—In stating his opinion that a broken stone aggregate must be better than a natural aggregate, he added that where you got broken stone, with sharp angles, there was a great deal more chance of getting a good binding in the material than when natural gravel was used.

Oxidation.—He considered that the oxidation in certain jetty work might be due to the vibration of heavy engines, but could not understand how mechanical vibration could affect a chemical change, and enquired whether vibration opened the surface of the concrete, thereby letting in water.

Architectural Treatment.—The speaker drew special attention to the fact that the great difference between reinforced concrete and ordinary buildings was that in ordinary buildings one dealt with a jointed material like masonry, but in concrete with what is essentially a monolithic material, and should be treated accordingly. A good many efforts had been made, especially in America, to show how very well reinforced concrete would lend itself to architecture, but the mistake they all made was to try to treat it just as they would treat a stone. Mr. Statham expressed the necessity for a treatment which is natural to the material and expresses the nature of the material.

MR. E. FIANDER ETCHELLS, F.Phys.Soc., A.M.I.Mech.E.

Aggregates.—Mr. Etchells stated that he would like to ask questions on three points. The first would be found in the chapter or section marked "Aggregates." About half-way down that chapter the author said that the proportioning of the ingredients of concrete by mechanical analysis had lately received considerable attention, and it had been found that curves could be plotted in the form of an ellipse with a straight line tangent, the abscissae being the sizes of the aggregate and the ordinates the percentages of the various sizes in the mixture. He desired to ask the author to show on the blackboard in what direction that ellipse was placed? The paragraph was far from clear. It spoke of a straight line tangent. The speaker had not yet seen a tangent to a curve which was not a straight line. Moreover, the paragraph did not show in which direction the ordinates of the curve were to be measured, or from what base-line. The axes of the ellipse might be placed in any direction. In addition to showing on the board it would be as well if a diagram were put in the book when the paper should be reprinted in the transactions.

Reinforcement.—The second point was with regard to the chapter headed "Nature of Reinforcing Metal." About the third or fourth line down in the chapter it spoke of a relatively small unit moment of resistance. The speaker desired to know precisely what the author's intention in regard to that was, because a unit moment of resistance was an inch-lb. or a foot-ton or an inch-ton, and what was a relatively small unit moment of resistance? He did not mean an inch-lb. It was possible his intention was to refer to the relatively small stresses on the beams.

Test Loading.—Then the next point was under the heading "Test Loading." Earlier in the paragraph it distinctly spoke of test loads, but it closed with two obscure sentences. One was the reference to the floors of factories and workshops where there was a certain amount of vibration, and it said that the super-imposed load was to be multiplied by 1½. It was possible that the intention there was that when you had multiplied by 1½ you got an equivalent dead-load, and if in the reprint of this paper Mr. Marsh would make it clear what his intention was, the speaker considered it would be useful.

SIR JOHN COCKBURN, K.C.M.G., Late Premier of South Australia.

Waterproofing.—Sir John Cockburn remarked that he did not think quite sufficient importance had been attached in concrete construction to the advantageous aid that could be derived from soluble silicates. Having made some experiments, more than 25 years ago, on silicate of soda, mixed with cement, he had found it had made a skin as it were, and he had been able to lay on with success a layer of cement on pre-existing cement of about ⅛ in. thick, which under no other process, he understood, could be made to adhere. He had often seen in this country, where so much skill and experience were available, the most disastrous results from attempts to put a thin layer of cement on concrete. It skinned off even if it was ½ or ¾ of an inch thick. In early days he had succeeded in placing a permanent skin of cement on concrete of only about ⅛ or ¼ of an inch thick. It was common knowledge that immediately the soluble silicate came into contact with lime it was converted into an insoluble silicate of lime, and this might prove valuable in waterproofing concrete constructions.

Life of Concrete Buildings.—It was the speaker's opinion that permanent structures are wanted, and that there is a greater chance of obtaining them through concrete construction than any other form. He considered that a new era was dawning upon building, and that concrete construction in addition to providing strength and permanance will evolve architectural features and an architectural beauty of its own.

MR. W. T. HATCH, M.Inst.C.E.

Lime Concrete.—Mr. Hatch said that within the last few years he had had some experience with lime concrete, and that when recently opening out the foundations of some boilers, where the temperature is anything up to 800 he had not found the slightest sign of disintegration.

MR. MORITZ KAHN.

Measurement of Cement.—Mr. Kahn gave it as his opinion that cement should be measured by volume and not by weight, as the better quality of cement weighs lighter than the poorer qualities. The contractor could thus use the highest grade cement at the same cost.

MR. D. B. BUTLER, A.M.Inst.C.E., F.C.S.

Aeration of Cement.—Mr. Butler stated that the lecturer's remark that the air slaking necessary for chamber kiln cement was unnecessary for that obtained from rotary kilns was due to the fact that it was impossible to use rotary kiln cement unless it was either gypsumised or otherwise dealt with, and that the reason why manufacturers, as a rule, did not like rotary cement to be aerated was not that it in any way detracted from its strength, but that it altered the setting time, which was a very important matter. Rotary kiln cement when it was first burnt was extremely quick setting, and impossible to use, and the only way of altering that was by watering or gypsumising. It had been found that if gypsumised cement was aerated it did not always remain slow setting; it frequently became quick setting again. And that was the reason why some manufacturers do not like their cement aerated.

Setting Time of Cement.—Referring to the setting time of the British Specification Committee, the speaker thought that the initial set was the most important omission in the present British specification. From a user's point of view it was more important for him to know how long he might work the cement without damage, than the time occupied in attaining " hard set."

Aggregates.—As long as the finely-divided clay was added to the sand, and did not exist in the sand as a coating round each grain of sand, it might be an improvement, but if the loam or the clay was a coating round each grain of sand, the cement naturally would stick to the coating of loam, and the strength of the mortar would depend on the adhesion between the loam and the sand, and not on the strength of the concrete. The speaker considered that the dryer the concrete was mixed, so long as it was sufficiently plastic for the water to come to the top, the better would be the strength, but there was also danger in getting it too dry.

MR. SHARROCK.

Setting of Cement.—Mr. Sharrock stated that he did not consider the initial setting of rotary cement so important. Rotary cement initial setting had been worked out very often from 15 to 24 to 36 hours for a final set.

Aggregates.—The speaker stated that when cutting through two different kinds of concrete the concrete made with dirty ballast was very tough, and could not be split, while that made with a clean Thames ballast could be broken off in large pieces.

SIR HENRY TANNER, I.S.O., F.R.I.B.A., Vice-President.

Sir Henry Tanner stated he must draw the discussion to a close. Those gentlemen who had not been heard might perhaps have an opportunity when a more specialised subject was under review, instead of one ranging over such a large field as the present one.

Concrete Generally.—The Chairman stated that there were two or three remarks he wished to make, as his experience of reinforced concrete was of comparatively recent date. So far he had found that a fairly watery concrete gave a better result in the end, and for reinforced concrete it was certainly more useful. Where a large amount of reinforcement was used it was impossible to get the thicker concrete down, so to speak, between the rods, and in the course of time the watery concrete seemed to get much harder than the other.

Waterproofing.—As to waterproofing, he had got a considerable length of wall, 26 ft. high, with the earth against it all round, and so far had not had a sign of water through it. It was only 7 in. thick at the top and 8 in. at the bottom, with some rough concrete to fill up where the borings were taken. 1 to 4 concrete had been used.

Protection of Steel.—As to the protection of steel, a good many experiments had been made, and in no case was the steel found to be corroded. It had been especially found that, with regard to ordinary coke breeze concrete, which had been used now for 25 or 26 years, where alterations and so forth had been made, the steel joists were in perfect order when opened up.

MR. MARSH, M.Inst.C.E.

The Lecturer's Replies.—The lecturer replied to Mr. Wentworth Shields that the proportioning could be regulated just as well with using definite volumes, because the sand and stone could both be of varying sizes.

With regard to the protection to the steel, from Mr. Shield's remarks it appeared that the oxidation was due to defects of design. It appeared that the vibration caused cracks and the moisture penetrated. It could not do otherwise.

In reply to Mr. Blount's statement that nothing had been said about the work of chemists in the improvement of cement, Mr. Marsh drew attention to his remarks that chemists have a great deal to do with the manufacture of cement.

In reply to Mr. Meik's remark that he did not agree in measuring the aggregates by weight, Mr. Marsh pointed out that his statement was that the present practice would probably be superseded by proportioning by weight of cement to volumes of sand and stone. With respect to certain suggestions which had been made on the question of waterproofing, Mr. Marsh remarked that silicates would form a hard surface, which would be of no use if cracks occurred, and this was the great danger of concrete.

With regard to Mr. Kahn's remark about proportioning cement by weight, the lecturer stated that engineers generally specify the quality of the cement, and do not leave the choice to the contractors.

In reply to Mr. Etchells, Mr. Marsh referred to an issue of CONCRETE & CONSTRUCTIONAL ENGINEERING,* in which he had dealt with the question of proportioning by mechanical analysis.

Regarding the unit moment of resistance, he pointed out that if one took the moment of resistance as M, and divided it by the breadth and the square of the depth, one would get the unit moment of resistance.

With regard to loads the lecturer stated that he seemed to have gone rather beyond the point; he had not quite followed the subject he was referring to—the test loading. Where he said "the weight of reinforced concrete is to be taken as" down to "multiplied by 2," referred to the calculations. It had slipped in there by mistake. These co-efficients were to be used in the calculations.

As to the employment of lime concrete in the construction of masonry dams, Mr. Marsh stated that the reason engineers used lime concrete for this purpose was that it took longer to set, and since such a dam is carried out in stages, the internal stresses will not occur if lime is used as a matrix, such as those which doubtless existed when Portland cement was used, due to its rapid hardening. Of course, in a gravity dam it was not so much the strength as weight that was wanted.

In reply to Mr. Bamber, the lecturer stated he simply said that it was quite usual to obtain a cement which would leave less than 15 per cent. on a 180 sieve.

With regard to a remark about using dirty ballast, he thought that it was advisable to use clean ballast if possible, although certain kinds of clay could be mixed with the cement and the concrete be improved; yet without tests he thought it would be foolish to use dirty ballast. Of course, if there is time to test a ballast and get the results of the tests, it was very probable one might get a stronger mixture, but there was also an equal chance that the concrete might be weaker.

After a vote of thanks to the Chairman, proposed by Mr. Kirkcaldy and seconded by Mr. Serraillier the meeting terminated.

THE SECOND MEETING.

THE EXAMINATION OF DESIGNS FOR REINFORCED CONCRETE WORK

PAPER by WILLIAM DUNN, F.R.I.B.A.

The Chairman, Mr. Edwin O. Sachs, F.R.S.Ed. (Chairman of the Executive), opened the proceedings by announcing that the roll of members and subscribers had reached 400.

MR. EDWIN O. SACHS, Chairman of the Executive.

The Reader of the Paper.—The Institute was to be congratulated upon having the particular question indicated by the title of the paper dealt with by the Chairman of the Institute's Science Standing Committee, who not only ranked as a leading exponent on all questions relating to reinforced concrete, but who has had considerable personal experience in the examination of designs on behalf of a certain Government department.

It had been an open secret that Mr. Dunn was one of the primary movers some years back in obtaining for the architectural profession the Reinforced Concrete Committee, which was formed by the Royal Institute of British Architects, and had been so ably presided over by Sir Henry Tanner.

Systematic Examination of Designs.—There could further be no doubt that the Paper was most *apropos* at the moment, for public authorities of all kinds and descriptions were considering the principles upon which designs for reinforced concrete work were to be examined and controlled.

Public authorities such as H.M. Office of Works required the additional check of a special examination for buildings erected at their expense. Authorities like the Local Government Board would in the near future have to examine designs for reinforced concrete in a systematic manner, and would eventually have to ay down a procedure for such examination.

Standardisation for the Examination of Designs.—The London County Council proposed to have new regulations for reinforced concrete structures, and would have to formulate some rapid and practical system by which, both at its central office and in the offices of the district surveyors, reinforced concrete schemes can be examined on standard lines, and what held good for London would shortly be applicable to cities like Liverpool and Manchester, for everywhere some effort would have to be made to standardise the methods for the examination of designs for reinforced concrete work.

The Chairman then asked Mr. Dunn to read his paper.

WILLIAM DUNN, F.R.I.B.A., Reader of the Paper.

The Advance of Concrete.—After a few introductory remarks, Mr. Dunn called attention to the fact that for very many years back engineers and architects had been accustomed to use concrete strengthened with steel or iron, but in an elementary way. Thanks to the labours of certain enthusiasts who, foreseeing the great future before reinforced concrete, bit by bit advanced the theory and practice of it to the present scientific adaptations of means to the end which was now common property, we had passed that elementary stage. These enthusiasts, generally speaking, were both designers and executants ; were not professional men, but men with fine constructive instincts, whose faith in their own power was attested by their carrying out their own works.

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*Vol. II., No. 4.

As the importance of their undertakings increased, the reinforced concrete firms called in to their aid professional engineers to prepare designs for the works tendered for, submitting design and tender together in a manner more usual in American than English practice.

Specialists and Systems.—As a result almost all the work of design as well as construction fell largely into the hands of specialist firms, claiming more or less patent rights either for the whole system of construction or for some special details of it.

These claims, while no doubt enlarging the practice of the individual firms, naturally operated in restraining ordinary designers from attempting work in reinforced concrete with a possible legal dispute in the background, and though it is now generally admitted that there are no exclusive rights in the ordinary combinations of steel and concrete, but only in some particular details which Mr. Dunn would not attempt to define, the lecturer stated, it was still the rule rather than the exception for those desirous of using reinforced concrete to invite designs and tenders from the specialist firms—the designs, of course, based on general lines—instead of, as usual in other branches of work, employing an engineer or architect to prepare the designs and conditions, and soliciting tenders thereon.

There was a great deal to be said in favour of this arrangement. It was reasonable to suppose that those who spent their whole lives in one class of work understood it better than those whose energies were distributed over several classes, and that efficiency and economy were both served.

Laws Governing Design.—If the work in question was tendered for by one firm only, the owners were largely in the hands of that firm as to price, and, though the lecturer disclaimed the slightest reflection on the contractor, it was but natural that he should prefer there should be no other tenderer for the same reason that the owner objects to it—namely, that the one was likely to pay and the other to receive a much better price. If, however, several firms were invited to tender, the designs submitted varied in regard to the method of construction, the reserve of strength, etc., and a fair competition and just choice between them became difficult. How were they, he asked, to decide if these designs were properly conceived, might safely be erected, and complied with the requirements laid down ? Whatever the structure might be, the general lines of it were no doubt determined by those inviting tenders, and the questions to be considered were primarily questions of strength and durability.

Rules and Methods of Calculation.—Fortunately we had now an authoritative pronouncement on the general methods of calculation to be adopted. Empirical and semi-empirical rules were no longer recognised, since we had for our guidance rules based on scientific reasoning, and giving results closely confirmed by experiment.

Mr. Dunn thought the rules laid down by the Royal Institute of British Architects' Committee on Reinforced Concrete undoubtedly formed a standard from which we ought not to depart without good reason.

Debatable Points.—In going through a set of drawings there were always debatable points calling for the exercise of judgment, cases in which we could not say definitely how the loads were borne. In these, Mr. Dunn stated, he would always discuss the matter with the designer, and give his views full weight before forming his own opinion. We could not, of course, agree that any patent system abrogated the ordinary laws of mechanics, and must take care that when they had to make assumptions as to the lines of action of loads or stresses, those assumptions were on the side of safety and logically followed out. There were always differences in design for which we might have a legitimate preference ; one design differing from another in being much more scientific in conception or neater in detail according to the skill of its author. But we must be careful to keep our preferences from becoming prejudices.

The position of the consulting engineer who had to examine and report or decide on competitive designs and estimates was one demanding considerable tact and common sense as well as professional qualifications. It should be considered how those designs had been prepared ; made not for actual work in hand, but only for possible work, with insufficient data and necessarily very brief study of the project. It was often a matter of wonder to the lecturer how such good designs were produced under the conditions.

Drawings submitted with Tenders.—The drawings submitted with tenders were generally meagre, and the serious difficulties of the undertaking commonly left for future consideration. Out of these projects, that of the lowest tenderer was selected for consideration, and the architect or engineer must satisfy himself as to the practicability of the design and as to its compliance with the conditions laid down before recommending it for acceptance. If he had not sufficient experience of this class of work, he might call in a consulting engineer who had made it a special study.

Was the engineer to require all the drawings, details, and calculations necessary for him to form an opinion on every point on recommending a tender for acceptance? Mr. Dunn asked. That would entail a very large amount of labour on the part of the contractor, which might be all thrown away. But unless the engineer had had these full details before him, unless he had carefully recalculated nearly every structural part to justify a particular instead of a general approval, there was room for serious dispute. Though the responsibility for the strength of the work was in every contract expressly put on the contractor, the engineer had a large moral responsibility that his opinion should be so carefully based on actual investigation as to be of genuine value.

He had heard many complaints from reinforced concrete firms of the unnecessary loss entailed on them by calling for detailed drawings to accompany tenders when the latter were asked for any particular piece of work. Of course, the contractor must usually prepare some rough drawings before tendering, but the expense of making fair copies was very considerable, and it might be possible to reduce this by asking only outline drawings, reserving the right to require details before acceptance of tender.

The cost of the drawings was a large part of the expense in reinforced concrete, and when contractors had to charge the cost of the preparation of many unsuccessful schemes on a few which are successful, the work is seriously handicapped. The reinforced firms could do something to economise labour if they required the necessary outlines to be supplied and did not supply details until after the receipt of the tenders, when the lowest tenderers, or the favoured tenderers, could submit the full scheme for consideration of the consulting engineer.

If in the specification upon which the tenders were invited the contractors were distinctly informed that the work was to be in accordance with the recommendation of the British Committee's Report, the stresses to be restricted to those given therein, and the drawings and calculations to be submitted to an expert for verification, the contractors would have no reason to complain if a design were found not to comply with the conditions. What they did complain of was that the competition system virtually tempts them to cut down the works to the lowest limit, and unless some proper examination was made the man who had honestly complied with the requirements might be at a serious disadvantage. If all the requirements were clear at the start, they all worked on a fair basis.

Points to be Observed in Checking Calculations.—In checking calculations the dead weight of the structure was a more important element than in other constructions, and should be carefully computed, not guessed at, and allowed for as part of the loading. The lecturer had sometimes found serious deficiencies in strength due to this want of precaution.

The amount allowed as a negative moment for fixing at the end of beams should be carefully considered. Mr. Dunn said he had end fixing claimed for beams freely supported, but all such errors were so capable of demonstration that disputes could be avoided. We should remember always that all our results depend on our assumptions, as a syllogism depends on the premises. If these were wrong, correct reasoning on defective premises was a positive danger.

Superintendence.—Suppose, however, that the design had been carefully checked, initial difficulties got over, and the work begun, the superintendence of the work was merely the transference of their anxieties into another field.

He was very strongly of the opinion that no work of importance should be entrusted to men without experience; our best safeguard against defective work was undoubtedly the skill, experience and honesty of the contractor.

No engineer or architect, unless he spends all his time during the execution of the work in actua and constant supervision, can secure his employer against dangerous errors on the part of the workman. In steel construction we can examine and measure every part after it is up; not so in reinforced concrete work. Once the concrete is laid we cannot tell but by cutting into it whether there are six 1-in. rods or two ½-in. rods inside a beam or pillar, or whether these are 2 in. or 4 from the surface. To see that the drawings are actually carried out requires a conscientious scrutiny and attention every minute of the time the work is being done. Much may be observed during a visit, but not everything.

Failures.—Notwithstanding all our care and forethought, we had sometimes trouble arising from obscure causes.

All work in reinforced concrete was looked on with jealous eyes by those who were not in favour of it. Every failure was magnified, every little accident was blazoned forth in the most vivid colours, not given to such great disasters in other systems of construction as the Quebec bridge. We should be doubly careful, in that these troubles involved the whole industry as well as ourselves, and though we might chafe at the injustice of our critics we might profit by the severity with which our mistakes were visited. When failures did occur let us do our best to discover the true cause, sparing no effort to do so.

The Chairman called upon Professor Beresford Pite to open the discussion.

PROFESSOR BERESFORD PITE (Professor of Architecture, South Kensington).

The Need for Experience.—Professor Beresford Pite stated that if there was one thing wanted more than another at the present day, it was not only contractors of experience, foremen of experience, clerks of works of experience, but architects and engineers of experience in the designing of reinforced concrete.

The Question of Design.—The speaker considered that, as far as the architectural treatment of reinforced concrete was concerned, there were means of expression in it, and there was as much force and virility in the thin wall as there was strength and solidity to be expressed in the thick. He suggested that not only the Science Committee of the Institute, but also an Art Committee, should give attention to the subject of design in reinforced concrete.

MR. R. W. VAWDREY, B.A., A.M.Inst.C.E.

Choice of Design.—Mr. Vawdrey stated his opinion that inviting competitive tenders upon the designs of one or more firms should be avoided if possible to prevent confusion of design and price. He thought it would be better if, when an engineer or architect was considering the construction of a reinforced concrete building, in the first place to settle the design, or the design it was proposed to adopt—*i.e.*, to invite competitive designs if desired from those who lend themselves out to prepare them—and, having settled the design, to obtain tenders from contractors upon it. It appeared a dangerous thing for the design, and the price at which the design could be carried out, to be confused in the selection of the final tender. For instance, where competitive architectural designs were required for some public building, it was after the acceptance, he understood, of the chosen design, that tenders were asked for its construction; yet the most usual practice at present in regard to reinforced concrete work was to ask for competitive tenders upon competitive designs.

The Use of the Word "System."—The speaker considered it a mistake to use the word "system" of design in reinforced concrete, as it was impossible to override the ordinary principles of mechanics in any reinforced concrete design, and the difference which might occur when designs are prepared by different firms, or different architects or engineers, depended entirely on the practice, whether good practice or bad practice was shown in the designs. There was no fundamental difference in system. All correct systems of design depended on the principles of ordinary mechanics, that could not in any way be ignored.

Failures.—Mr. Vawdrey, in agreeing with Mr. Dunn that a mishap might not be dealt with scientifically in this country, suggested that in any case of failure a committee of members of the Concrete Institute, or some portion of the body, should be appointed to deal with or investigate, if necessary more or less privately, any important case of failure that might occur.

MR. G. C. WORKMAN.

Choice of Design.—Concerning the question of the choice of a proper design, Mr. Workman said that it was very important that architects and engineers should realise that, unless the rules of the British Committee on Reinforced Concrete were applied, it was quite possible that either the steel or the concrete, in certain parts of the design, might be stressed beyond the limits which had been specified. He was of the opinion that when competitive designs were required from various firms of specialists, it was essential that the architect should state that the calculations must be based upon the rules of the British Committee, or that if any empirical rules were used the specialist should be asked to justify that the limit stresses fixed by the British Committee had not been exceeded. The architect should check these figures or calculations to see that this was done, for undoubtedly certain abbreviations and simplified methods adopted by some contractors, while giving correct results in some cases, did not give correct results in others. The rules of the British Committee were quite reasonable and workable, and architects should specify their application in every case.

Failures.—With regard to what Mr. Vawdrey mentioned a few minutes ago, supposing any failure did ever occur in a work with reinforced concrete, the speaker questioned as to who should see in a scientific manner the reasons for which this failure had occurred. What rules were to decide and fix the responsibilities? It was generally known that the rules which had been put forward by the British Committee had not been publicly accepted by everybody, but engineers ought to know what was going to determine the responsibility of the engineer in the case of any failure, and Mr. Workman thought the Institute should take up the matter with a view to defining precisely what would happen in such a case.

MR. E. P. WELLS, J.P., Hon. Treasurer.

Choice of Design.—Mr. Wells stated he had always found that where several specialists had sent in designs exactly on the same lines, and adopted the same factors throughout, those quantities having been sent to contractors, there had been very little variation really in the cost of the work, and he thought that variation had been primarily due to the amount of profit that had been added; but in cases where there was a difference of 33⅓ per cent. between the highest and the lowest, it was certain that some serious error had been made, and that the factors, which ought to be 4 to 1, were down sometimes as low as nearly 2 to 1. In all cases where an architect or an engineer asked for prices for reinforced concrete work, he should state what his factor was and should give a certain stress per square inch in his steel.

Mr. Wells then quoted a number of interesting examples to show the uncertainty of building owners knowing exactly what they required. With regard to the work designed by the speaker, he stated that though 1,000 lbs. was his figure—he never went beyond, in the South of England, 600 lbs. per sq. in. under compression ; and if he found he was running beyond that he simply made up the difference in steel.

Results of Tests.—Referring to Mr. Dunn's statement that better results are obtained from the tests of cubes than from work in actual practice, the speaker stated that he found that if a cube of concrete is cut out of the concrete that has been put *en masse*, or even to a larger size than the cube itself, the crushing resistance would generally be from 25 to 50 per cent. greater than the small cube, owing to the fact that the moisture in the small cube evaporated so rapidly as compared with concrete in large masses, as it was evident that the mass of moisture in the concrete enabled the cement to gain in strength, and also become very much denser, owing to the pores being filled up with the crystals of hydrate of lime.

Crushing.—Mr. Wells said it had been proved by experiment, as he had had cubes under lever crushing machines for over 10 days, with an instrument registering to $\frac{1}{2000}$ of an inch, and he had never found yet that if he loaded up to 63 per cent. of his ultimate he got any permanent set ; in fact, with a very good concrete made out of spurn gravel it might be made up to 75 per cent. of the ultimate, and then it was absolutely safe.

Detailed Drawings.—Mr. Wells stated that he made a point of not supplying detailed drawings until the tender was accepted.

Dead Weight.—In agreeing with Mr. Dunn about the dead weight of a structure, Mr. Wells said it was one of the things, when works are tested, that was not taken into account, and was one of the prime causes how it was very often that when a beam or a floor was tested it always broke, if the concrete was good, at very much more than the calculated allowance. And that was due entirely to the dead load being constant throughout and only increasing the live load. That was a point that he thought might be considered later on by the Institute, as to whether in floors where there is an enormous amount of dead load a greater allowance should not be given, because the factor is, say, 4 to 1 on that dead load which remains constant, and it is only the live load that is increased.

Gypsum and Cement.—On the Continent it is very common to find gypsum in cement. Mr. Wells had several reports sent to him showing where tunnels and retaining walls had simply collapsed in a space of 12 months, and in one case where the water was taken from the site and 3 : 1 briquettes and neat briquettes immersed in the same, complete disruption had taken place in one month.

MR. H. K. G. BAMBER, F.C.S.

Cement.—In referring to the subject of gaining experience by failures, Mr. Bamber stated that the particular German iron ore cement of which the lecturer spoke, was invented to meet the question of the supposed deterioration of Portland cement in certain sea waters. It was thought that the action was caused by a decomposition of the alumina present in the cement, together with the magnesium sulphate present in the sea water, and the formation of sulpho-aluminate of lime, and in order to prevent that action the idea was to produce a cement with the raw material in order that the finished article might contain the smallest possible percentage of alumina. In this way, by using silica and iron ore, a cement could be produced containing a very small percentage of alumina. The ordinary percentage in British and German Portland cements was about 6 per cent. or a little under ; but in this case, using these materials, a cement had been produced with a little less than 1 per cent.

This particular cement must not be confused with the iron ore cements or rather the slag cements which were prepared from vitrified waste material from blast furnaces, or the vitrified waste material of iron ore. The difference between these cements was that in the iron ore cement there was a very small percentage of alumina, in the case of the slag cements, prepared from blast-furnace slags, there was no less than 15 to 20 per cent. of alumina as compared with the 6 or 7 per cent. that was to be found in an ordinary Portland cement.

Distinction of Cements.—The speaker referred to the author's statement that in Germany there was a distinction between cements required for land work and cements for sea work ; whereas in England such was not the case, and said that during the last few years the English manufacturer had placed himself in a position to meet such a distinction if required, and if requested he was able to supply material which was practically free from gypsum, which was one of the objectionable ingredients of cement to be used in sea water. Users of English Portland cement had not experienced the difficulty referred to, and had yet to learn that modern English cement could not be used with perfect satisfaction under all conditions in sea water.

MR. W. G. PERKINS (District Surveyor).

Strength of Concrete.—Mr. Perkins, referring to the paper, said it was stated that the British rule for concrete under compression in bending was to allow a maximum of 600 lbs. per sq. in., and then it was added that from experiments made with cubes under direct compression, it was only safe to put 500 lbs. per sq. in. on the concrete. He thought it contrary to general experience. When a material was tested under transverse stress, it generally showed a higher coefficient of strength than when tested under direct tension or compression.

MR. J. MUNRO.

So-called Specialists.—Mr. Munro gave it as his opinion that there were too many so-called "specialists," and stated that if an architect wanted his work properly done he should go to those who thoroughly understand it.

Choice of Design.—Mr. Munro also expressed his belief that tenders should be submitted on a uniform design. He considered that architects ought to give definite indications of what they required. The contractors should be told what the value of the concrete should be, what the steel should be stressed at—the factors of safety or the coefficients.

With regard to preparing working drawings, he did not think these should be insisted upon until the tender had been accepted, as the expense was very great.

MR. H. B. GATES, A.M.Inst.C.E.

Internal Stresses.—Mr. Gates, in referring to Mr. Dunn's statement that a beam or pillar in reinforced concrete was subject to the same laws as any other bodies, said that a great many people had not seemed to realise it. The bending moments, the moments of resistance, the external and the internal stresses, were developed in exactly the same fashion as in wood or steel members, but the internal stresses were complicated by the fact that the beam or pillar was not homogeneous but composite. All such matters were questions of fact, to be determined by the ordinary methods of applied mechanics so far as they might be determined, for it was to be remembered that the relatively exact results obtainable in a jointed steel frame, in which the stresses must act along certain defined lines, or in a homogeneous steel beam, of a material whose qualities are fairly uniform and constant, could not be hoped for in a reinforced concrete structure which was not jointed.

Hooped Concrete. — Regarding Mr. Dunn's statement, "Before the hooping comes fully into action there must be large stresses in the concrete, nearly equivalent to the full ultimate strength of the plain concrete, and very considerable change of form which would be objectionable in many cases," Mr. Gates said he did not think that was quite correct; in fact, it was quite contrary to all the experience of M. Considère, which was considerable. If efficiency is looked for in concrete, there was no more severe test to which you could put it than to put the hooped column, or any other kind of column advocated, into the form of a pile and hammer it, and if it was an efficient column, and if it obeyed the laws which it was supposed to obey, the stress developed by the hammer driving the pile a considerable length on a rock bottom would show whether the column was efficient or not.

Checking Calculations. — Further, in reference to Mr. Dunn's remarks as to the points to be observed in checking calculations. "In checking calculations the dead weight of the structure is a more important element than in other constructions, etc." Mr. Wells had also made remarks on the dead weight in respect of testing. That was not checking calculations, but testing. He fully agreed with Mr. Wells that it was necessary to allow for the dead load in checking the test. If a 50 per cent. overload was taken, and no allowance made for the dead load, the overload was only about 30 per cent., which did not give you what it was supposed to give.

Negative Moments.—Mr. Gates spoke of the rule of the Reinforced Concrete Committee on this point, which he regretted was not generally observed, and said that the question of negative moments is a point which requires every consideration.

Checking of Members.—The speaker considered that the way to get over the difficulty of uncertainty as to whether the reinforcement was correct was to use a method of construction, or reinforcement, in which all the reinforcing members of a certain area or a certain member were first placed completely in position, and wired together in their proper place. If such a complete skeleton method was adopted there would be no difficulty whatever in checking the members before the concrete was put in.

Choice of Design.—The speaker further stated his entire concurrence with the remarks of some of the foregoing speakers on this point.

MR. CHAS. F. MARSH, M.Inst.C.E.

Compressive Resistance in Bending.—Mr. Marsh said he had always found that the compression in bending was greatly in excess of the compression under direct pressure. The cause of this was, he thought, that the less strained fibres helped the more strained fibres in resisting the stress; consequently one got apparently a greater resistance in compression when the piece was subjected to flexion than when it was directly compressed, and it was a well-known fact that a cast-iron beam, for instance, was very much stronger than if it was calculated on the assumption that it would only have the same resistance as it had under direct compression.

MR. EDWIN O. SACHS, F.R.S.Ed., Chairman of the Executive.

Mr. Sachs stated he must draw the discussion to a close.

Choice of Design. — The Chairman stated that, in his opinion, the whole tone of the discussion pointed to the fact that all parties would be satisfied if the Reinforced Concrete Committee's regulations were kept to. In this way both contractors and building owners would be safeguarded. No one had in the course of the discussion raised any serious objection to the Committee's recommendations.

This being the case, one could only advocate that engineers and architects should in the fewest possible words simply write at the top of their specification for reinforced concrete that the regulations of the Reinforced Concrete Committee were to be strictly adhered to, and all parties would be served.

So-called "Specialists."—Mr. Munro had brought out a point regarding the influx of the number of so-called "specialists" of moderate attainments or no attainments at all. Architects and engineers could only protect themselves against these so-called "experts" by adopting some recognised conditions for designs and work, and further by adopting some standard form of examination for designs, and a recognised form of routine for supervision of the execution of the work. Standard forms already existed to a certain extent for steel work.

Drawings for Designs.—Regarding the unnecessary work, specialist designers are often called upon to do when submitting designs, this should have the meeting's sympathy. It was really quite ridiculous to see the trouble to which some specialist designers were put by members of the different professions, who did not exactly know what they wanted. But it must always be remembered that we were dealing with an entirely new form of building construction so far as this country was concerned, and a certain experimental period must still exist in the architect's office, and in the engineer's office, and that many an architect really did not know quite what he wanted, beyond that he had heard that reinforced concrete was stated to be economical, that he wished to obtain a design and examine it. His examination frequently led to his becoming a regular user of reinforced concrete. It was very regrettable that unnecessary trouble was given, but the matter should right itself in a few years as architects and engineers generally become more conversant with the various forms of reinforced concrete available.

MR. WILLIAM DUNN, F.R.I.B.A.

The Lecturer's Replies.—Speaking of the column invented by M. Considère, Mr. Gates questioned his statement that it suffered considerable change of form before the steel binding became effective. He (Mr Dunn) had seen columns which were stressed in the testing machines, where the conditions were favourable for measuring the swelling and the deflection, and he had noticed very considerable deflections. All scientific tests would show that there were these deflections, and while he valued M. Considère's work, and also his column very highly, he did not think we had got such a perfect understanding of it as he hoped to see.

In replying to Mr. Perkins and various others questioning his statement that the actual concrete in our beams would bear a less load than the concrete in cubes, Mr. Dunn, before this meeting came on, went through a large number of records of very carefully made experiments and tests upon beams, in which the concrete of which the beams were composed had been previously tested in small cubes, and found that in nearly all cases the small cubes showed a higher result per square inch than the concrete in the beams. He thought it probable that this was due to the concrete in the beams failing at some weak spot, and we were more likely to get a weak spot in a long length of beam than in a small 6 or 7 in. cube. The concrete beam did not always fail at the point of maximum stress. It failed probably, if under compression, near the point of maximum stress, but the exact spot would be determined by some small weakness in the column, which might account for the discrepancy Mr. Perkins mentioned, and Mr. Wells also.

Mr. Dunn thought Mr. Bamber's remarks were most interesting, and he hoped for a better cement for sea water in the future.

In reply to Mr. Wells, Mr. Dunn thought he was right in saying that Mr. Wells assumed that 75 per cent. of the ultimate was a safe load.

He considered this a more optimistic view of the matter than his own. He had known plain concretes fail very suddenly when they were not reinforced. When reinforced, of course, they failed more slowly, but he thought that the very high stress spoken of would be distinctly unwise to use at present.

Mr. Dunn stated he was glad that it seemed to be generally accepted that the Reinforced Concrete Committee's requirements were practical, and reasonable, and workable, and that the concrete makers themselves admitted that, because he thought there was every likelihood of their being embodied in by-laws, as they are at present accepted by various public authorities. He believed the County Council themselves accepted them, not in by-laws, but in their everyday practice of examining reinforced concrete works.

The Chairman thereupon announced that the meeting terminated.

NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

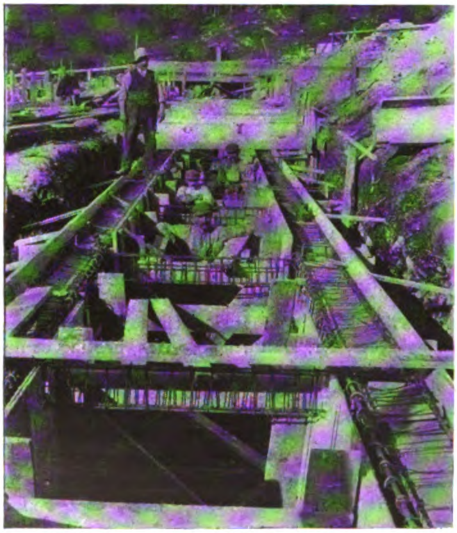
Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED

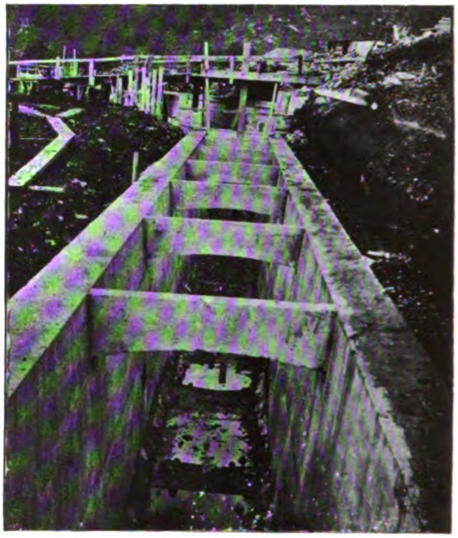
REINFORCED CONCRETE CULVERT AT KINLOCHLEVEN, N.B.

THIS work has recently been completed for the British Aluminium Company at Kinlochleven, Argyllshire, under the supervision of Mr. Alban A. H. Scott, architect.

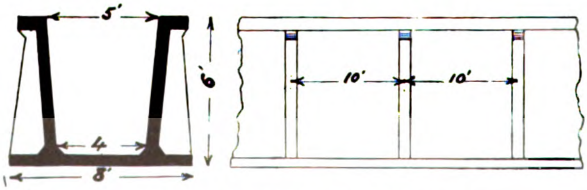
The contractors and licensees were Messrs. McLaughlin and Harvey, of Belfast.

The total length of the work is about 500 ft. The height of the culvert is 6 ft. 6 in. and the average width is 4 ft. 6 in. As shown on the accompanying section the wall slabs are 5½ in. thick, reinforced with a meshwork of bars, and the foundation slab forming the bottom is 4 in. thick, similarly reinforced.





Buttresses have been placed at intervals of 10 ft., these also support the longitudinal top beams. Arched struts are thrown across between the buttresses, and these are designed to carry a light railway.



The bars employed for the reinforcement are plain round bars of mild steel, varying in diameter between $\frac{3}{16}$ in. and 1 in.

It will be remembered that one of the advantages of the Coignet system is the facility afforded by the use of ordinary commercial bars of circular section.

The mixture of the concrete is in the proportion of 3 parts of "Ferrocrete" Portland cement to 5 of sand and 10 of crushed rock. The inside of the culvert was rendered with ½ in. of sand and cement.

Part of the work is founded on rock; the greater part, however, was constructed on ground of varying consistency, periodically water-logged.

The unreliable nature of the ground, composed partly of large boulders and soft earth, necessitated very careful consideration in preparing the design. We think, therefore, that this culvert is a very good example of the adaptability of reinforced concrete, and should be of considerable interest to those who are contemplating carrying out works of this class.

REINFORCED CONCRETE BRIDGE AT THE YORK RACE-COURSE.

We illustrate in this article an important reinforced concrete construction, which has just been completed at York. The construction has several unique features, and will, therefore, prove of interest to our readers. It contains a through girder span of 74 ft. 9 in. in the clear, the floor being suspended from the bottom of the girders. In addition to this, the bottom of the main girder is not straight, but has a rise of about 3 ft.

These two peculiarities entailed special treatment in detailing, which will be discussed later.

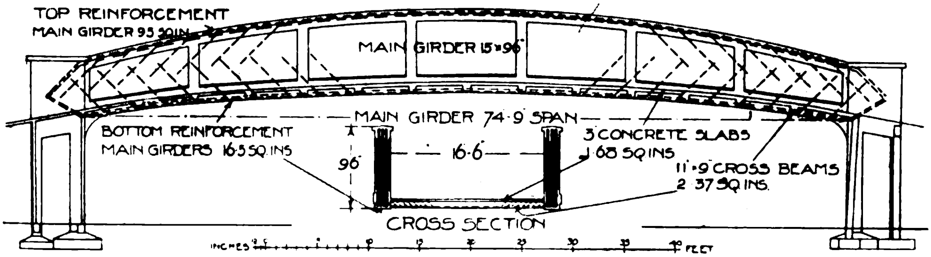
When the York Race Committee decided to remodel their grounds, the problem presented itself of preventing interference between foot and carriage traffic where the main road is 70 ft. wide, and, in order to provide a safe crossing at this point, the Committee decided upon constructing a bridge over the roadway from a raised embankment on one side to a raised approach on the other, the approach leading down towards the enclosures.

Conditions were such that it was found advisable to start the structure at the close of the May Meeting, and to have it completed ready to be used at the August Meeting. Therefore, time of completion and safety of construction were the main elements of the contract.

The contract was awarded on the 10th of June, 1908, and stipulated that the work was to be entirely completed on or before the 1st of August—a trifle over six weeks later. At one time it was thought necessary to have the bridge built of structural steel, and the approach of reinforced concrete, as the difficulty of constructing a 74-ft. span in six weeks was quite apparent. When enquiries were made, however, it was found out that the structural steel could not have been delivered at the site in time, let alone being erected, therefore the contractors had to fall back upon a reinforced concrete bridge.

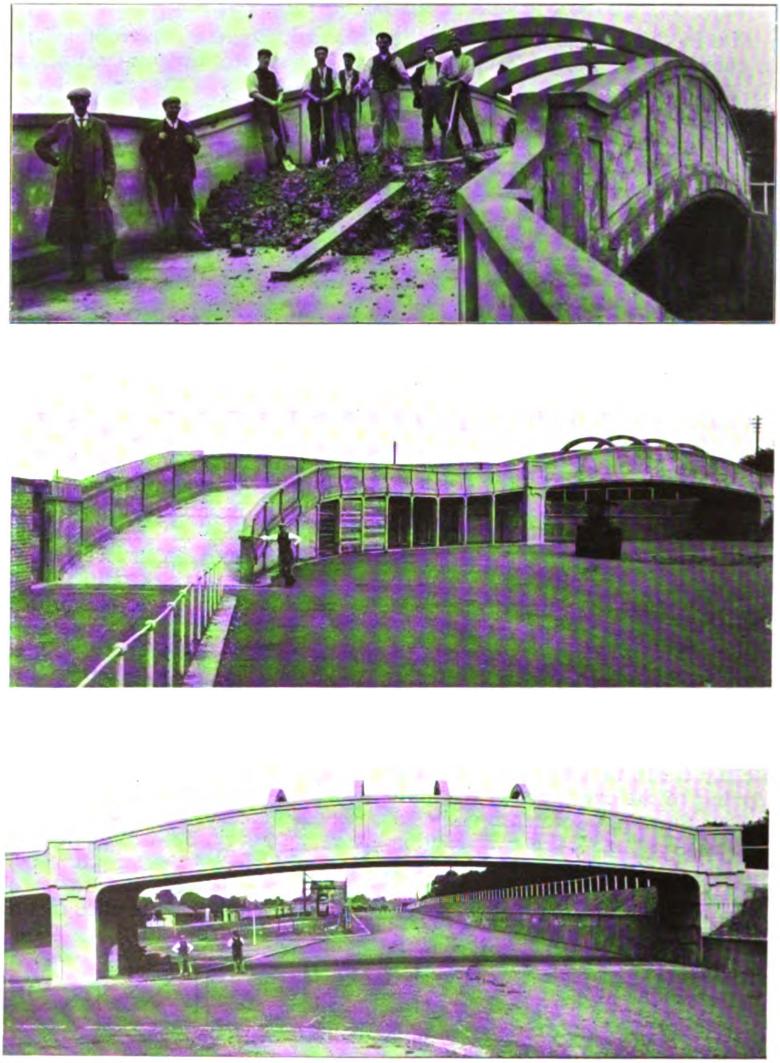
In order to complete the structure within the time allotted work was started at both ends by two gangs of men, one working on the bridge, the other working on the approach. By this means the work was entirely completed five weeks after the signing of the contract, or one week ahead of time, proving that reinforced concrete, when properly handled, is a rapid mode of construction. The structure is about 250 ft. long, and the clear width between parapet walls is 15 ft.

Referring to the curvature of the bottom cord of the main girders, this would lead one to believe that they were designed as arches. An arch of such slight rise, however, would have necessitated the construction of very heavy abutments, at considerable expense. In order to eliminate this, the engineers designed the structure as ordinary straight girders, carried on four heavy stanchions. These stanchions were encased with a 5-in. wall, so as to give the appearance of abutments at the ends of the span.



York Race-course Bridge (showing reinforcement)

The first difficulty to present itself lay in the fact that when a structure is designed as a straight girder, the steel in the bottom comes in direct tension, and under this stress tends to assume a straight line from point to point of support. If this had been allowed to take place in the structure in question the steel would have pulled out of the line of curvature, and away from the mass of the concrete. Therefore special precautions had to be taken to prevent this by binding the main tension members rigidly up into the mass of the concrete.



York Race-course Bridge.
(Showing the approach and completed erection.)

The second difficulty lay in suspending the floor to the bottom of the girders, and in order to do this the reinforcing bars of the secondary beams supporting the floor slab were turned up into the mass of the girder concrete, special precautions being taken for the shearing strains at the ends of the secondary beams.

The bridge had to sustain a safe load of 1½ cwt. per ft. super. The weight of the concrete itself was assumed at 150 lb. per cub. ft.

The main girders of the bridge were used as parapet walls, and since the floor was carried at the bottom of the girders, a considerable reduction in the height of the embankment was produced.

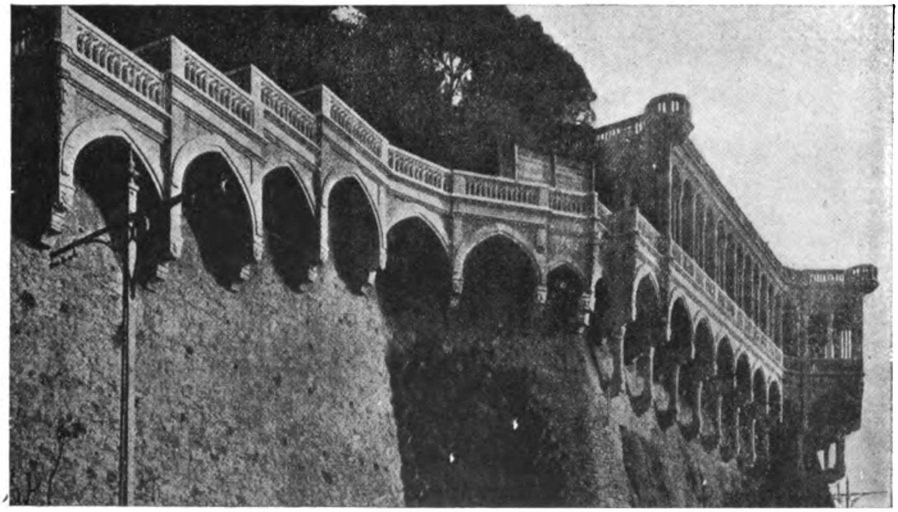
In accordance with the R.I.B.A. recommendations, reinforced concrete structures should be tested with a load 50 per cent. in excess of the safe load, 60 days after the completion of the work, and under this test the deflection should not exceed 1-600th part of the span. This being the first construction of its size and kind in England it was desirable to test it before being used for the August Meeting, and as it was impossible to wait 60 days for the test, a test was carried out 30 days after the removal of the centering. Under the safe working load of 1½ cwt. per ft. super. over the entire bridge the deflection at the centre of the span was about ⅛ in. This load was left on overnight, and the following morning the test was continued, with an additional 50 per cent. of load. Under this load the deflection at the centre of the span was a trifle over ¼ in., or 1-3,500th part of the span. The total weight of earth used in the test was 126 tons.

When it is recalled that, in accordance with the R.I.B.A. recommendations, a deflection of 1-600th part of the span is allowable 60 days after the completion of the structure, while a much less deflection than this occurred in the test only 30 days after the completion, it will then be realised that reinforced concrete, properly designed and carried out offers a very strong material for structural purposes.

The concrete was composed of 2½ parts pit ballast, screened through a ¾-in. mesh, to 1 part cement and 1½ parts sand.

The architect of this construction was Mr. Walter H. Brierley, of York. It will be noted that in the design the architect did not attempt to imitate stone construction in any manner whatsoever.

The specialist engineering designs for the structure were prepared by the Trussed Concrete Steel Co., Ltd., of Westminster, using the Kahn trussed bars, and the work was carried out by Messrs. William Moss & Sons, of Loughborough.



Reinforced Concrete Loggia at Genoa.

LOGGIA OF REINFORCED CONCRETE.

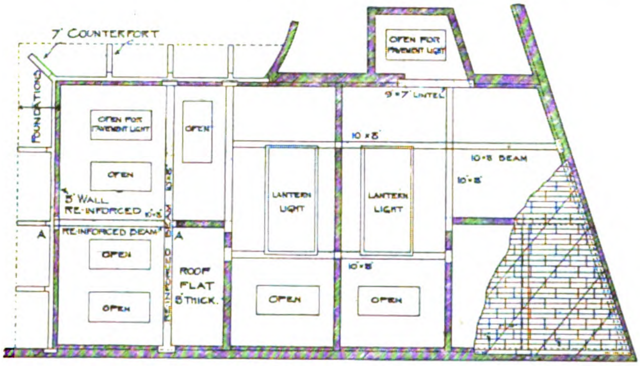
This loggia was constructed on the Hennebique system and appeared originally in *Le Ciment Armé*, when a reference was made to a general drawback in reinforced concrete—*i.e.*, the æsthetic inferiority of some of the work. So far as the Genoa loggia is concerned, however, it shows the peculiar adaptability of concrete. Even if it had been treated in the most simple manner, and with entire absence of ornamental detail, it should have been possible to make the structure expressive of its purpose.

REINFORCED CONCRETE IN THE CONSTRUCTION OF UNDERGROUND LAVATORIES.

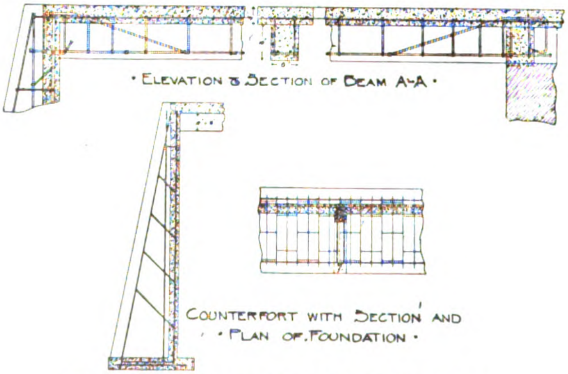
Reinforced concrete has been used to great advantage in municipal works of various kinds, but we have not met with an instance in England of its having been adopted in work of the above nature. Mr. Ernest R. Matthews, A.M.I.C.E., F.G.S., Borough Engineer of Bridlington, however maintains that for purposes of this kind it is eminently suitable, and we present herewith his description of its intended use in connection with the reconstruction of the Beaconsfield Lavatories at Bridlington under his supervision.

These lavatories were built about 15 years ago, and have of late years been found to be altogether inadequate. It was therefore recently decided by the Town Council to reconstruct and considerably enlarge them at an estimated cost of £1,200 (which, of course, is the estimated total cost of the completed work). The roof, which had given a great deal of trouble, was to be stripped off, and a new one substituted. The author decided to make the lavatories about twice their previous area, to hold up the adjoining ground, where the extensions occurred, by means of a reinforced concrete retaining wall, strengthened by reinforced concrete counterforts, and to cover in the building by means of a reinforced concrete roof, supported by reinforced concrete beams. The concrete used in the works is composed of 3 parts gravel capable of passing through a 1-in. ring, 2 parts sea-sand, and 1 part best Portland cement of an approved brand. The steel used for the reinforcement is of the best British manufacture, capable of withstanding a tensile strain of 67,000 lbs. per sq. in., and all steel for at least 12 hours before insertion in the concrete received a coat of cement grout. In no case is the steel nearer the outer face of the concrete than 1½ in.

The roof is covered with Limmer asphalt, 1 in. in thickness, laid in two layers. No forms were removed until a period of 14 days had elapsed since the concrete was filled in.



Plan of Roof.


• ELEVATION & SECTION OF BEAM A-A •
COUNTERFORT WITH SECTION AND • PLAN OF FOUNDATION •

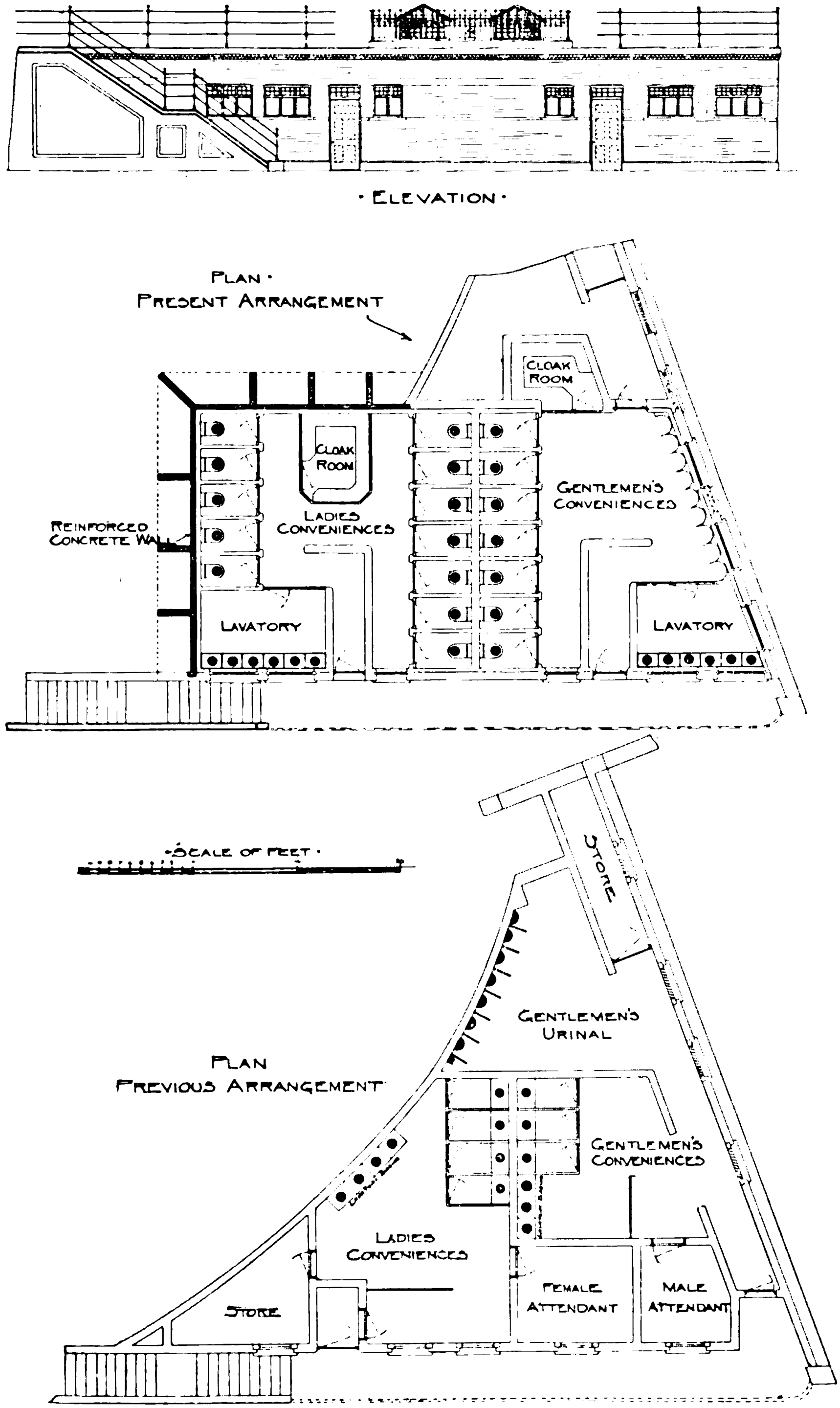
Reinforced Concrete Underground Lavatories.

Particulars of Reinforced Concrete Retaining Walls, Columns and Roof.

Retaining Wall Foundations.—The wall has a foundation 4 ft. 3 in. wide by 7 in. deep, projecting 9 in. beyond the face of the wall. The reinforcement consists of ⅝-in. round mild steel bars, spaced 6-in. centres, and held in position by patent steel clips.

The longitudinal reinforcement consists of No. 2, ⅜-in. shear bars, locked to transverse bars with special clips.

Wall and Counterforts.—The wall is 5 in. in thickness, and is reinforced by ½ in.



Reinforced Concrete Underground Lavatories.

rounds bars fixed longitudinally at 6-in. centres with clips at 20-in. centres, and the vertical reinforcement consists of ⅞-in. shear bars spaced 3-ft. centres, and secured in position by clips.

The counterforts are 7 in. in width, and reinforced in a similar manner.

Columns.—These are built into the new brick walls, and are intended to carry the ends of the reinforced concrete beams. They are 1 ft. 9 in. by 9 in. and 13 ft. long, and are reinforced by four ⅞-in. round bars and one ½-in. bar with diagonal and transverse clips.

Roof Beams.—The beams supporting the roof are 10 in. x 8 in. in section, the short beam or lintel over the entrance to the cloak room in the gentlemen's lavatory being 9 in. x 7 in.

They are reinforced by ⅞-in. bars cranked in an upward direction towards supports, with transverse and vertical clips as shear members.

Riser beams will support the lantern lights; these are 6 in. deep by 5½ in. on soffit, and reinforced by ⅝-in. bars with clips as shear members.

Roof.—This is 5 in. in thickness, and reinforced by ½-in. bars fixed at 6-in. centres with clips, diagonal shear bars being spaced at 3-ft. 6-in. centres, and then locked by means of clips to ½-in. bars.

Mr. Matthews having built several underground lavatories, estimates that quite 30 per cent. in the cost will be saved by adopting the method of construction just described, instead of building a heavy retaining wall, and covering the lavatories with a massive concrete roof supported in the old-fashioned way by steel joists spaced about 3-ft. centres.

For notes on the precautions necessary in the actual carrying out of reinforced concrete work, see articles on Reservoir Construction by the same author, and which appeared in Nos. 1 and 2 of Vol. III.

REINFORCED CONCRETE IN TELEPHONE EXCHANGES.

In our previous issue we published particulars relating to some modern telephone exchanges constructed in reinforced concrete in and around London, and we now have pleasure in presenting photographs and working drawings from several other Exchanges for which the United Kingdom Fireproofing Co., Ltd., of Westminster, have provided the whole of the steelwork, the reinforced concrete lintols, the fire-resisting floors and roofs, and, in some cases, the fire-resisting partitions and staircases.

There are six Exchanges, and they are situated at Manchester, Hillhead (Glasgow), Dalston, Chester, Bromley, and Cambridge. We name them in rotation according to size, Manchester being an exceptionally large one, the contract price being nearly £10,000.

The whole of these Exchanges are constructed on the above-named company's system of reinforced concrete, which is fully explained in the working drawing, and the floors are calculated to carry loads of 2¼ cwt., except in the apparatus rooms, which are taken at 6 cwt. per ft. super. In many instances this is not sufficient, however; for example, in the Glasgow Telephone Exchange the floors had to carry as much as 20 cwt. per ft. where the coil and relay racks came. This, of course, required special calculation and reinforcements, as the loads were concentrated in the centre of spaces.

The greatest care has to be exercised in carrying out these buildings, the headroom has to be to exact measurements, and the holes in floors to within one-eighth of an inch.

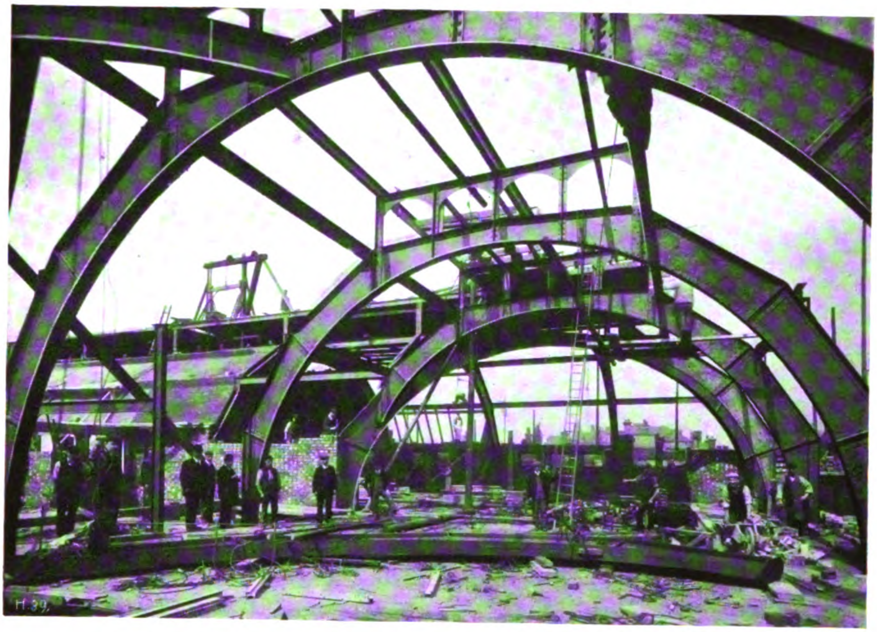
The photograph of Dalston Exchange shows the reinforcement in the roof, which is 20 ft. from flat to wall plate, and a very steep pitch, necessitating special reinforcements to obviate the sliding tendency.

The photograph of the Manchester roof shows a very awkward and complicated piece of steelwork, the huge hip principal, shown at the return, is of 60 ft. span, and is intercepted at different intervals by two half-principals and two three-quarter-principals. The total weight of the hip principal is 11 tons.

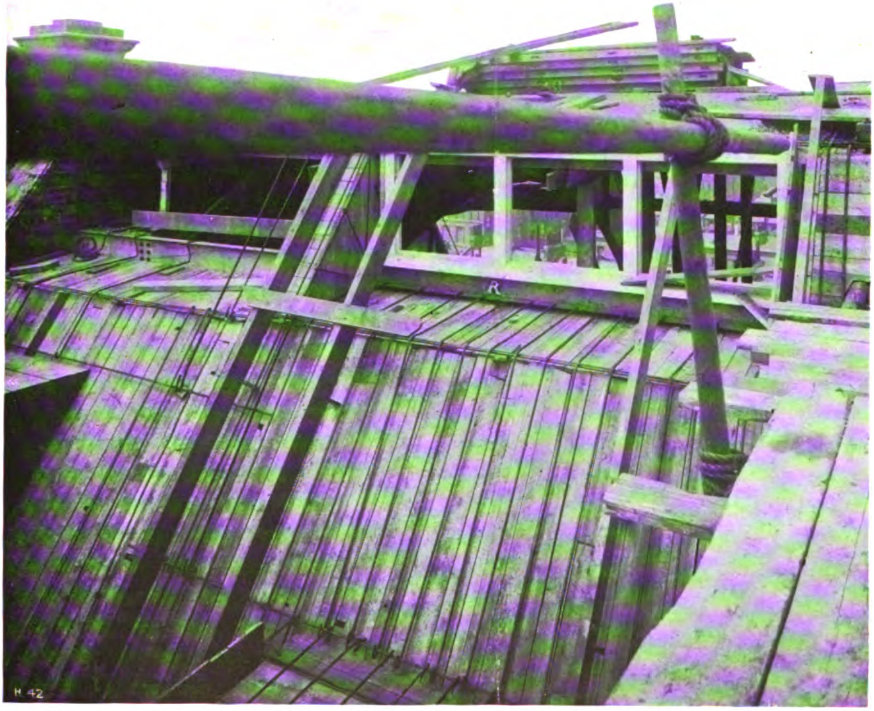
The floors were tested by the Partick Borough Survey for the Glasgow Exchange, particulars of which, taken by Messrs. Warren and Stuart, of Glasgow, who were acting as independent Engineers, is as follows:—

Result of Test.

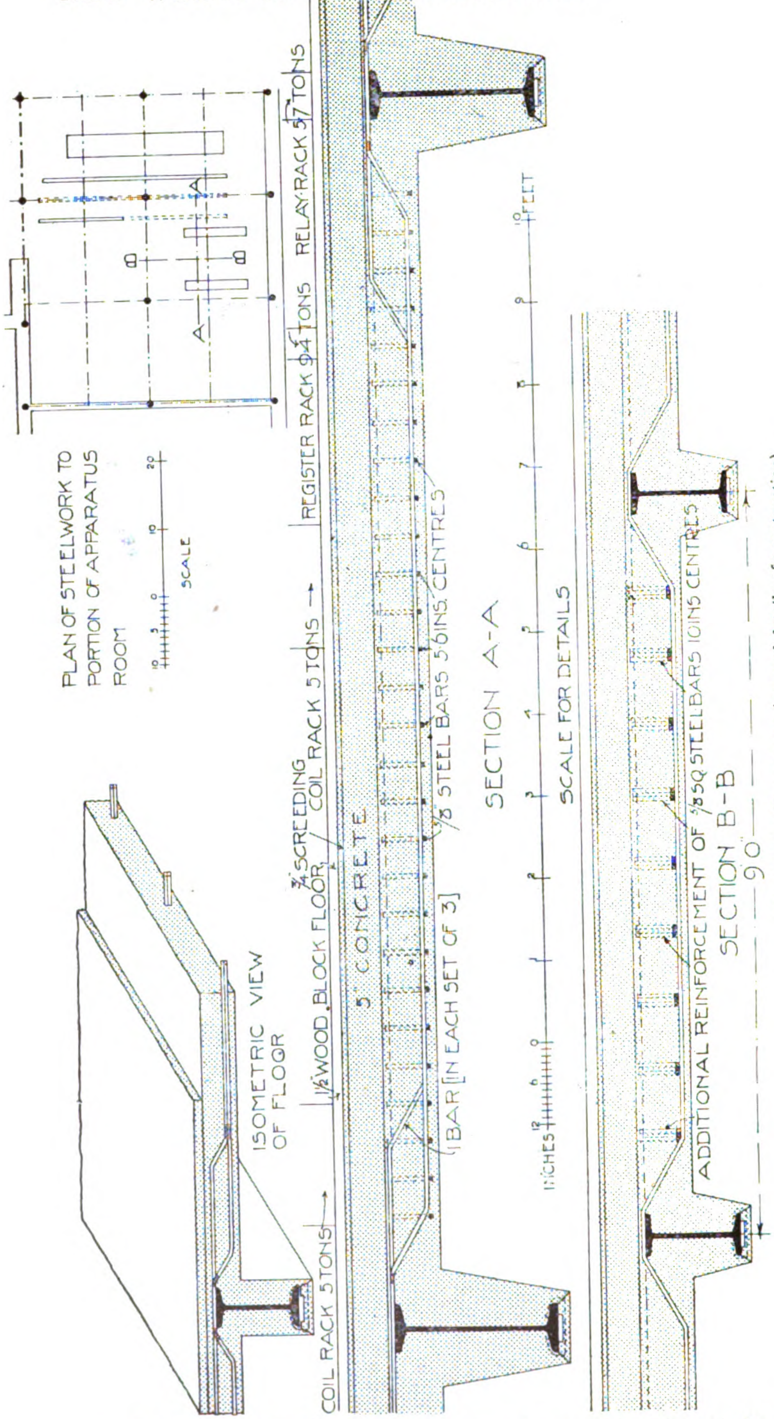
The test was carried out on a slab 18 ft. 6 in. long, measuring from the front wall to the



MANCHESTER TELEPHONE EXCHANGE (showing steelwork).



DALSTON TELEPHONE EXCHANGE (showing roof).



TELEPHONE EXCHANGES (general details of construction).

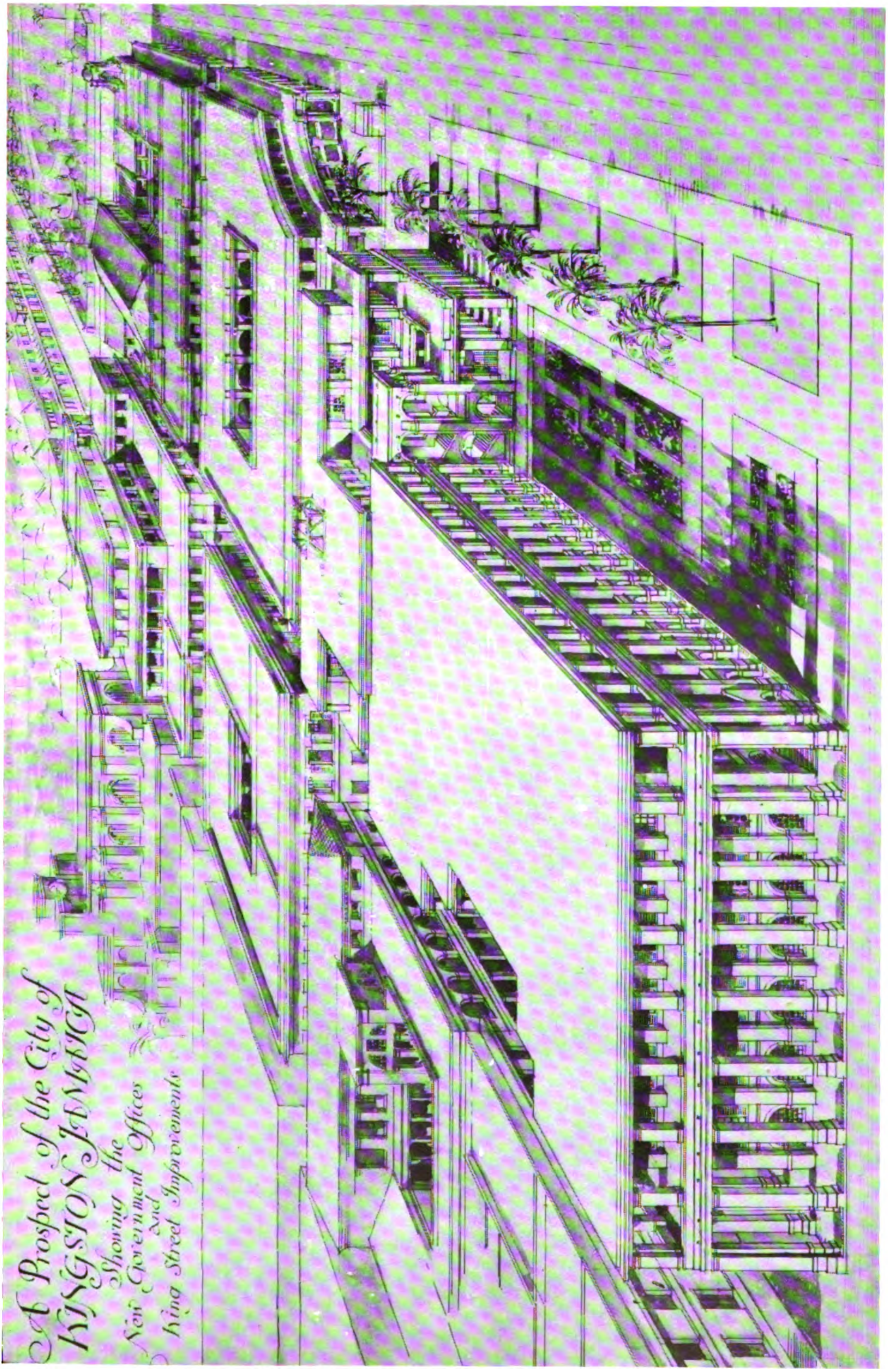
centre of the girder, and 14 ft. 6 in. wide from centre to centre of the supporting side girders. The loaded area was a strip of 8 ft. in width in the centre of the longest span and measuring 116 sq. ft. in superficial area. The concrete was 7½ in. thick over all and was composed of 1 part of Portland cement to 6 parts of aggregate, and the aggregate consisted of 2 parts of sharp sand to 4 parts of hard burnt clinker, broken to about ¾ in. ring. The concrete was five weeks old when the floor was tested.

The deflection was measured at the centre of the slab by a simple lever multiplying actual deflection by four, which transferred the movement to an indicator clear of the slab to the side. The floor tested was calculated to carry a live load of 1¾ cwt. per sq. ft.

Five observations were made between 11.30 a.m. and 12.55 p.m. with loads of ·71 cwt. per sq. ft., 1·46 cwt. per sq. ft., 2·26 cwt. per sq. ft., 2·95 cwt. per sq. ft., and 3·63 cwt. per sq. ft. respectively, and the detailed results are given in the following table. A maximum load of 421·5 cwt. or 406 lb. per sq. ft. was applied, when the total amount of the deflection at the centre of the slab measured 21-64 in., or 1-530th of the short span. On the removal of the load the indicator returned to zero, and there was no evidence of the concrete cracking or of deterioration of any kind.

The safe calculated stress on the concrete was just under 500 lb. per sq. in. compressive, and on the steel reinforcers 12,000 lb. per sq. in. tensile.

Taking into account the dimensions of the slab between the end and side supports, the result of the test is highly satisfactory.



Reinforced Concrete in the Rebuilding of Kingston, Jamaica.

NEW GOVERNMENT BUILDINGS IN REINFORCED CONCRETE AT KINGSTON, JAMAICA.

THE new Government Buildings which are now being erected at Kingston, Jamaica, are being constructed in reinforced concrete. The photograph which is given shows a general view of the new public buildings, among which are the Treasury, General Post Office, and the King's House. The latter is to be the residence of the Governor.

The designs for these buildings have been prepared by Messrs. Nicholson & Corlette, architects, of London, and the works are being carried out by Messrs. William Cowlin & Son, contractors, of Bristol, who are specialists in the erection of reinforced concrete structures, and are licencees of the Coignet system.

In preparing the design the architects and Messrs. Edmond Coignet, Ltd., have had to consider the question of earthquakes, and consequently the foundations for these buildings will be constructed in such a manner as to offer the least possible obstruction to shocks or movements of the ground.

The construction of these foundations is practically in the form of rafts, the slabs containing a strong reinforcement of steel bars of round section, which are always employed in the Coignet system.

The buildings themselves will be of the type which is usually adopted in hot climates, and they will be surrounded by verandahs, and the columns supporting same are to be artistically decorated in concrete. The roofs will be flat, and will be covered over with several inches of gravel. The cement used will be the "Ferrocrete" Brand.

To give the reader a brief idea of the method of reinforcement, the greater number of the pillars will be square and contain four or eight vertical bars of about 1 in. diam. These will be arranged symmetrically and bound with a spiral tie throughout the length of the column. These columns will support the principal beams, which will be of rectangular section. The skeleton steelwork of these beams will be made up of several straight bars of about $\frac{3}{4}$ in. diam. in the bottom or tensile parts of the beams, and a corresponding number of bars of smaller section in the upper part. These bars will be connected by thin steel stirrups of round section of about $\frac{1}{4}$ in. or $\frac{3}{16}$ in. diam., in order to take the shearing efforts. The smaller beams will be dealt with in a similar manner.

The slabs will contain a meshwork of small section bars, which will be placed in the lower portion of the slab to resist tension. There will also be a large quantity of rods to work as braces connecting the various steel frameworks and the columns, beams, and slabs in such a manner as to ensure a monolithic structure.

The scantlings of the posts will vary from 18 in. by 18 in. to 24 in. by 24 in., and some of them are to be of octagonal shape.

The average span of the beams supporting the floors will be about 20 ft. At right angles to these beams will be the secondary beams of a slighter scantling—namely, 12 in. by 7 in.; 4 in. will be the average thickness of the slabs.

It is also worthy of note that the staircases and balconies are to be constructed in reinforced concrete.

NEW USES FOR CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented as to new uses to which concrete and reinforced concrete are put, with data as to experience obtained during the experimental stage of such new applications of these materials. The use of reinforced concrete as a substitute for timber in exposed positions is one of the questions of the moment. Railway sleepers, telegraph posts, fence posts, etc., of concrete are being tried. Similarly, efforts are at present being made to prove that reinforced concrete is an excellent substitute for brickwork, where structures of great height are required.—ED.

CONCRETE FENCE POSTS.

In other countries fence posts of concrete are being extensively used, and their manufacture has become an extensive industry, and has been brought to some perfection. We have given instances from time to time of concrete fence posts made abroad, and in our last issue also illustrated some made in England. The subject is of such economic importance, however, to the landowner that we would again revert to the subject at some length. Thus we would now give a few examples of manufacturing methods, which will, no doubt, be of interest to our readers.

Fig. 1 shows the Victor Concrete Fence Post Machine. It consists of an improved screw feeding device which proportions the material and forces it into the boot of an elevator, which carries it up and throws it into the mixing bowl, where it is caught by a series of ploughs, and is turned over as the water is applied by a revolving sprinkler. The bottom of the mixing bowl is opened by a slide, which allows the material to feed into the mould, which is round and made from sheet steel. Four moulds with the reinforcement already in place stand on a reel, ready to be filled, small end down.

As the mould is filled it is raised 120 times a minute to consolidate the concrete, and when complete another is turned into its place.

It is claimed that moulds can be filled at the rate of sixty an hour. When

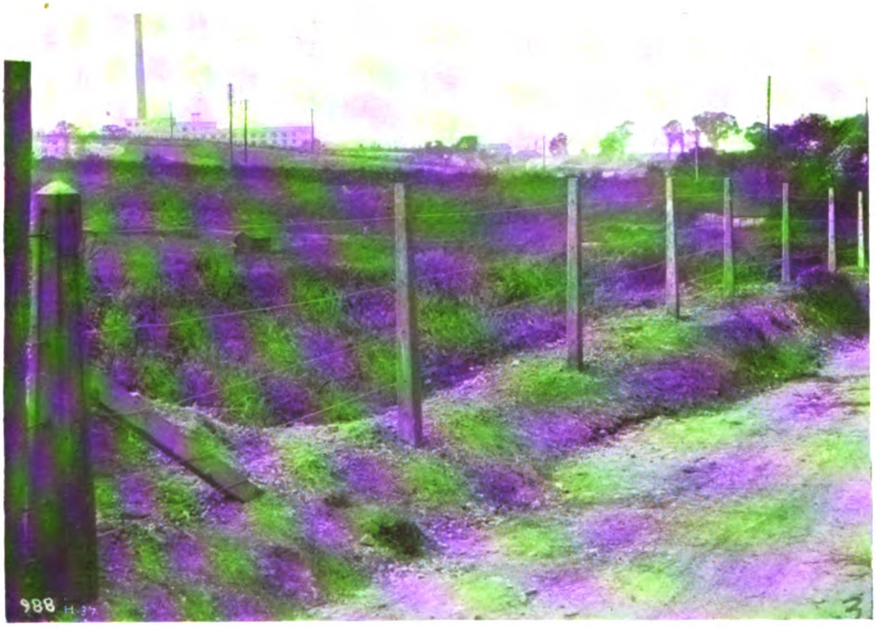


FIG. 3. REINFORCED CONCRETE FENCE POSTS ERECTED AT SWANSCOMBE

finished the mould is picked up by a small crane and placed upon a rack, where, after about twelve to sixteen hours, the moulds may be removed and the posts left to season for a month, when they are ready for use. It is claimed that with this machine three men can turn out 200 a day, and that a post 7 ft. long, 5 in. diameter at the base, and tapering to 3½ in. diameter at the top can be made

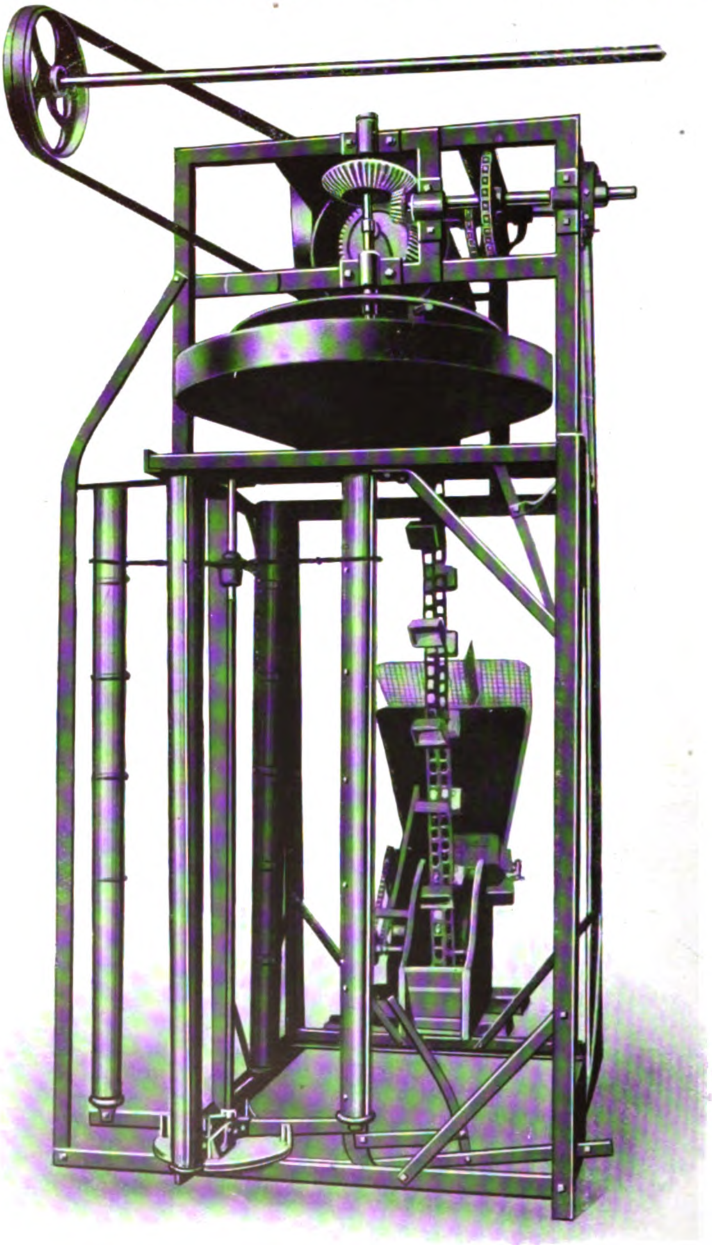


FIG. 1. THE VICTOR FENCE POST MACHINE

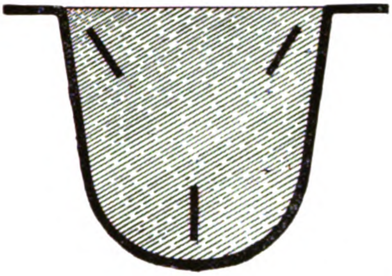


Fig. 2.

for 17½ cents. in the United States (8¾d.), as below :—

Concrete	6½
2 lbs. reinforcement	6
Labour and expense of plant	5
	17½

It seems to us that the cost of labour and expense of plant would come out greater than stated by our American friends, but even so the concrete post will compare favourably with the wooden one, given normal facilities and average labour in the United Kingdom.

The " D and A " Post Mould Company prefer to mould posts horizontally. They also use sheet steel moulds, *Fig.* 2 giving a cross section of their post and mould. These moulds are placed on a rack, which is shaken for a few minutes after moulding, thereby causing air bubbles to rise to the surface.

Several other types of mould are in the market, which want of space prevents us from describing. In all cases, however, metallic moulds are used, timber being too liable to warp and crack when exposed to the alternate wetting and drying. Only when a few posts are required should wooden moulds be used, and it will generally be found cheaper to buy the ready-made posts in such cases.

Fig. 3 shows a piece of fence recently erected at Swanscombe, near Gravesend, on an estate belonging to the Associated Portland Cement Manufacturers, Ltd. The ordinary posts are 6 ft. long and of square section, with the corners chamfered. The straining posts are 7 ft. long with a concrete strut and plate. *Fig.* 4 shows the straining post adopted in connection with these posts. It is supported by a concrete strut, bearing on a flat plate 15 in. square, which is embedded in the soil. These straining posts ought to be embedded 3 ft. when placed in soft ground, while 2 ft. is sufficient in harder strata. The struts may be 3 by 2 in. or 3 by 3 in., and the plates about 2 in. thick, reinforced with expanded metal on the underside.

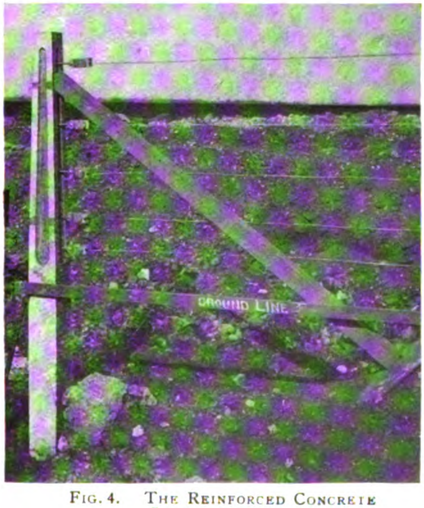


Fig. 4. The Reinforced Concrete Straining Post.

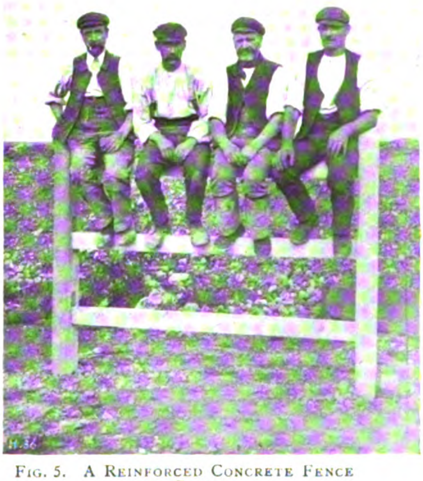


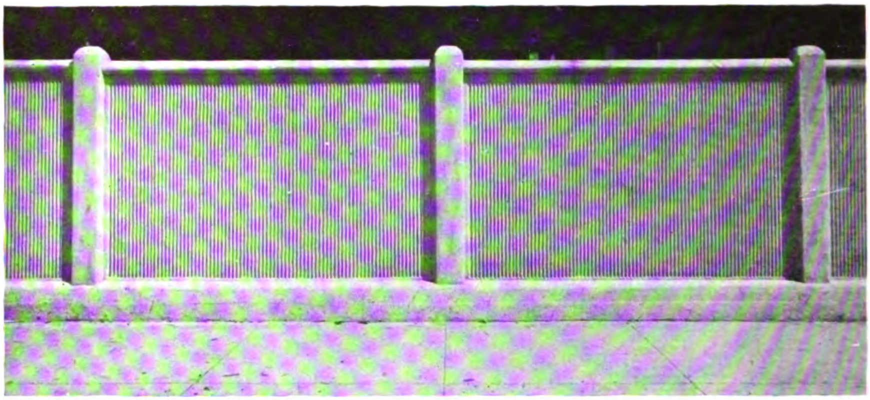
Fig. 5. A Reinforced Concrete Fence with Rails.

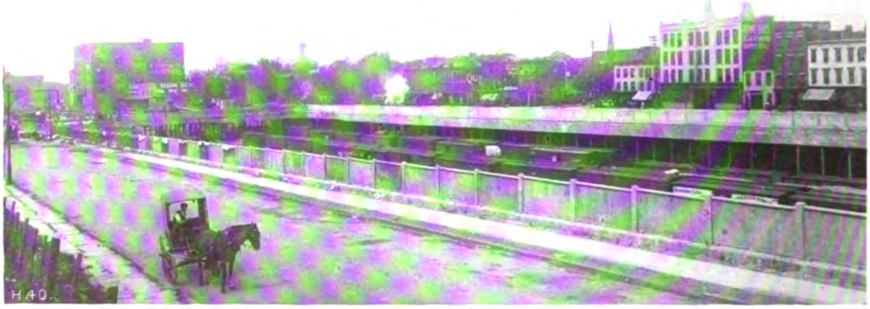
Similar posts without struts can be used all along the fence if a better appearance is desired, the extra cost being about 33 per cent.

It will probably be conceded that these compare very favourably in appearance with the best wooden posts, and are certainly much cheaper in the long run, as they neither decay nor rust, and are free from fire risks.

In the following tables are given the market price for good oak posts, and the *prime* cost (including loading) of reinforced concrete posts. Particulars of other types of concrete posts are also given :—

		Oak.	Concrete.
Line Posts A.	6 ft. long, 4¾ in. sq. at bottom, 2¾ in. sq. at top ...	2/1	1/7
Line Posts B.	7 ft. long, 6 in. sq. at bottom, 4 in. sq. at top ...	4/4	2/1
Straining Posts C.	6 ft. long with 1 plate and 1 strut	—	4/7
Straining Posts C.	6 ft. long with 2 plates and 2 struts for corner posts	—	7/-
Rail Posts D.	7 ft. long complete with 3 rails and 3 wedges	—	7/10

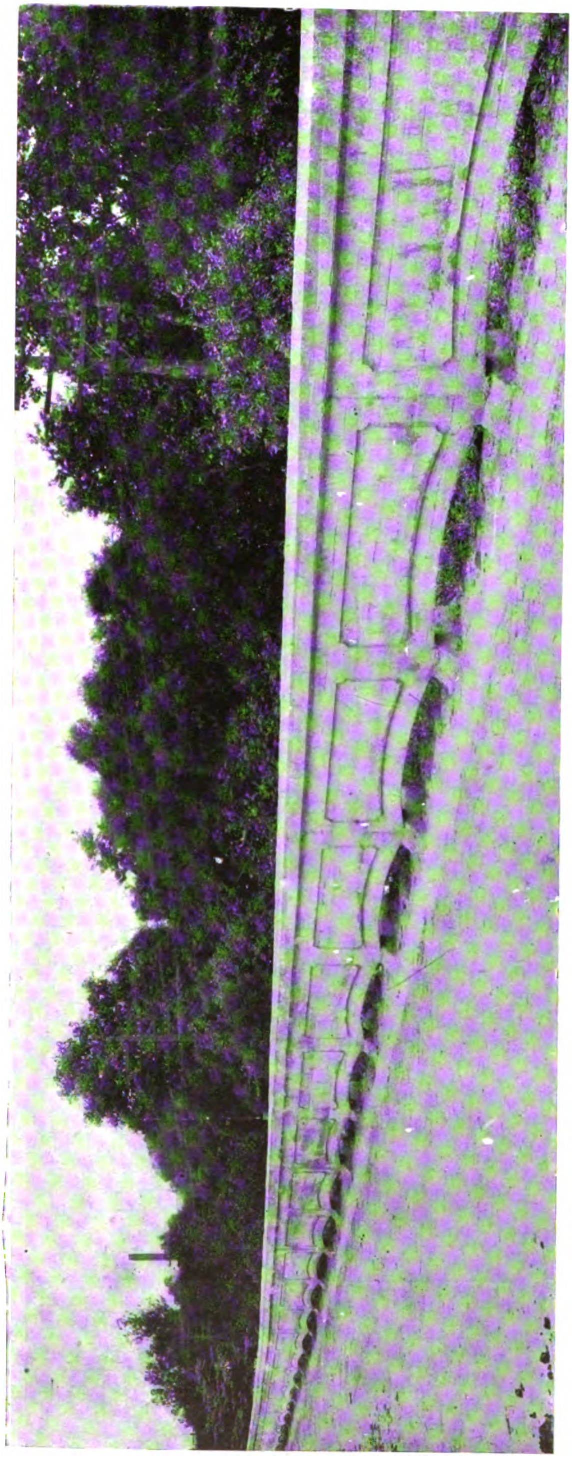




REINFORCED CONCRETE FENCE WALL AT THE ATLANTIC AVENUE TERMINAL OF THE LONG ISLAND RAILROAD CO., NEW YORK.

Fig. 5 shows another type of concrete fence provided with rails. To enable a broken rail to be cheaply replaced the holes in the posts are made large enough to allow one rail to slide over another. When erected the top of the hole is filled with a concrete wedge, which may be set with cement mortar.

We understand that the Associated Portland Cement Manufacturers, Ltd., now use concrete posts exclusively on their estates, and are prepared to give detailed particulars of their experience with them.



Concrete Fence Wall, one mile in length, extending from the Wabash River Bridge to West Terre Haute.

A LIGHT CONCRETE FENCE WALL.

The concrete fence wall, of which we present two illustrations, has been built in connection with the Long Island improvement scheme at the Atlantic Avenue Terminal, New York.

The sidings are separated from the street by about 300 ft. run of solid concrete fence, about 3 in. thick, very securely fastened to a large and heavy concrete curb. The 10 ft. panels were made of rectangular uniform slabs with a fluted outer surface, formed by using sheets of commercial corrugated iron for the backing of the wooden moulds in which they were cast. The horizontal upper edge of the slabs were made thicker, and rounded somewhat like hand rails, the lower edges were chamfered or hollowed to clear the coping, except at supporting points, about 6 in. wide midway between the posts, where bearing was provided for them.

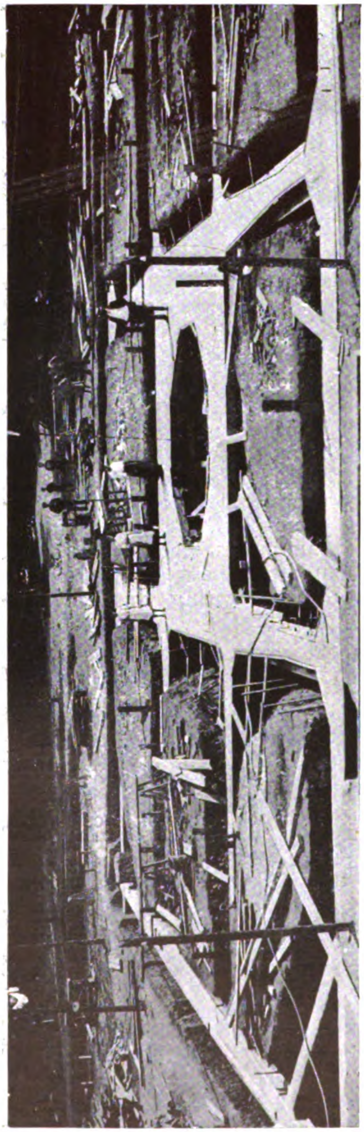
Each slab was reinforced with $\frac{3}{8}$ in. vertical rods 18 in. apart on centres, and with four horizontal lines of $\frac{1}{2}$ in. and $\frac{3}{8}$ in. rods. Vertical concrete posts with rectangular cross sections 7 in. square, each of them reinforced with $4\frac{1}{2}$ in. vertical rods, were cast in place on the concrete coping. Slots in opposite sides of the posts hold the ends of the slabs in position, and the slabs being cast in place after the posts have been thoroughly set. The slab is anchored to the post by divergent projecting ends of horizontal rods, and the posts were anchored to the curb girder by two $\frac{3}{4}$ in. vertical projecting rods.

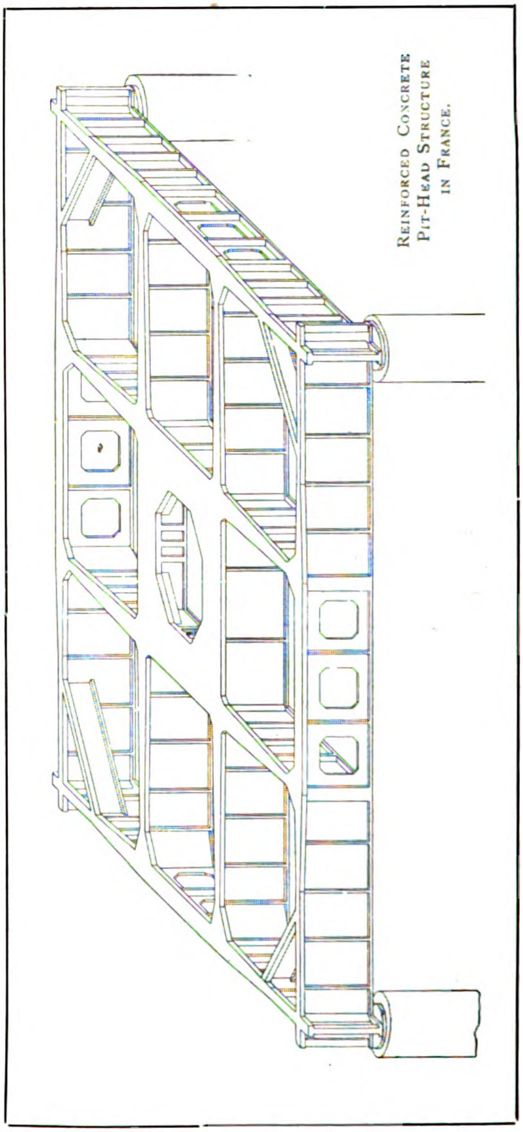
We are indebted for our illustrations to Mr. J. R. Savage, chief engineer of the Long Island Railroad.

A CONCRETE FENCE WALL.

This fence wall, extending from the Wabash River bridge to West Terre Haute, is one of the most interesting pieces of work of its type.

The concrete fence wall stands 4 ft. high, and extends a distance of one mile, and it is constructed in such a manner as to appear monolithic, although built in sections of some 20 ft. in length.





Reinforced Concrete Pit-Head Structure in France.

We are indebted for our illustration, which explains itself, to the *Cement Age*, of New York.

A REINFORCED CONCRETE PIT-HEAD STRUCTURE.

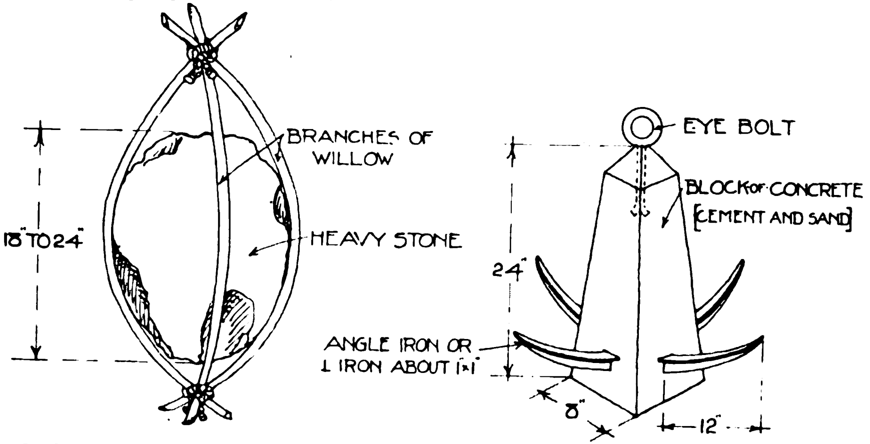
The work to which we refer has recently been completed on the Coignet system for the Société des Mines de Houilles de Marles, France.

This structure is interesting, as it contains several features which are novel and show a new application of reinforced concrete.

The above mentioned company were desirous of reconstructing their shaft, No. 2, which had collapsed about 40 years ago owing to water damage, and it was found necessary to suspend the new shaft to a structure having its points of support outside the radius of the old pit head. Four masonry blocks were built situated 28m. centre to centre for this purpose; and it is upon these points that the new main beams of reinforced concrete are resting. The shaft, weighing about 200,000 kgs. (about 197 tons), will ultimately be supported by the secondary beams by means of suspension bolts placed round the opening, which measures 6m. diam. It is also intended to use this structure for the foundations of the pit head building and machinery.

The masonry blocks are 3m. diam., and the beams transmit upon them a load not exceeding 2 kgs. (4½ lbs.) per sq. cm.

In order to give a better idea of the work we show a photo taken after completion and a perspective drawing.



It is obvious that such an enormous load, placed in the centre of these considerable spans, necessitated beams of unusual height and a corresponding dead load.

The four main beams are 3m. high, and the secondary beams are 2.70m. high.

It will be noticed that all the beams are made with upper and lower flanges and a webb; in certain parts the latter contains openings; stiffening uprights are provided to increase the rigidity of these enormous beams, one of the chief difficulties being to prevent them from distorting.

This remarkable work was very carefully tested, and the permanent deflection of any of the beams did not exceed 3mm., which is an excellent result, taking into account the magnitude of the load and the spans.

We think this example should go far to promote the use of reinforced concrete in many of our mines and collieries, where the question of treacherous ground is by no means uncommon.

REINFORCED CONCRETE ANCHORS FOR FISHING NETS.

An entirely novel use for concrete is to be found in the anchors which the fishermen have lately begun to use off the coast of Denmark. Up to about two years ago the nets, particularly those for catching eels, were kept in position by an arrangement of willow boughs round a large stone (see sketch), but one of the fishermen on the coast of Zeeland invented the idea of a block of concrete reinforced by angle irons. We understand that the cost of one of these concrete anchors works out at about one shilling, and that they are cast by the fishermen themselves.

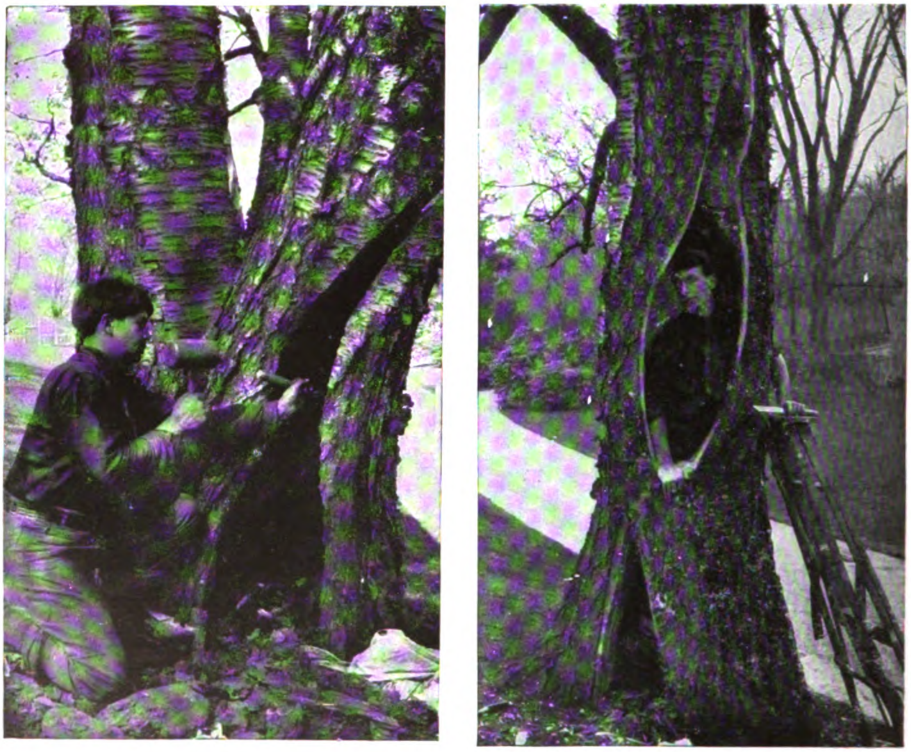
We think this is an idea which might well be adopted by our own fishing industry, as a practical and economical form of weighting the nets.

THE USE OF PORTLAND CEMENT FOR THE MAINTENANCE OF TREES.[*]

I AM frequently asked the question: "What is tree surgery?" In so far as it applies to the cement work alone a good answer would be that it is the practical application of dentistry to trees. But this answer would not cover the many other branches of the profession, consisting of trimming, chaining, packing, scraping, spraying, and fertilizing. Tree surgery is, in fact, an advanced development of arboriculture.

Both fruit and shade trees are valued now as never before, and the fact has become generally known that by skilful methods of the tree surgeon it is possible to give a new lease of life to trees which apparently had reached their limit of existence. I believe it is safe to say that almost any tree of medium age may be saved by these methods.

Of the many branches embraced in this work the cement filling forms by far the largest and most important part. The practice of filling cavities with cement has long been in use, but when carried out along the usual lines it only serves to add to the original trouble. The method of sealing up the decayed section simply increased the decay. Many examples may be seen where the bark at the side of the cavity was covered by the cement, no regard having been paid to drainage or the subsequent healing of the wound. As the cement did not stick to the wood and the swaying of the tree by the wind often enlarged the crack between the wood and the filling, water penetrated behind the cement, and decay went on even more rapidly than before.



Maintenance of Trees.

Removing Decayed Matter. Every Particle of Decay Removed.

The tree grows in girth by the deposit of a thin layer of new wood between the wood and the bark. There are three layers in this coat—the middle one being composed of thin forming tissues known as the "cambium." The inner side of this layer forms new wood, the outer new bark. It is this new layer and the layers of the four or five previous years which are known as the sapwood, and form the active section of the trunk and branches. The cells of these inner rings are gradually covered by the yearly deposit of new growth, and from living sapwood become heartwood, which is dead, and serves merely as a strong framework for the living parts of the tree and as storehouses for excess material.

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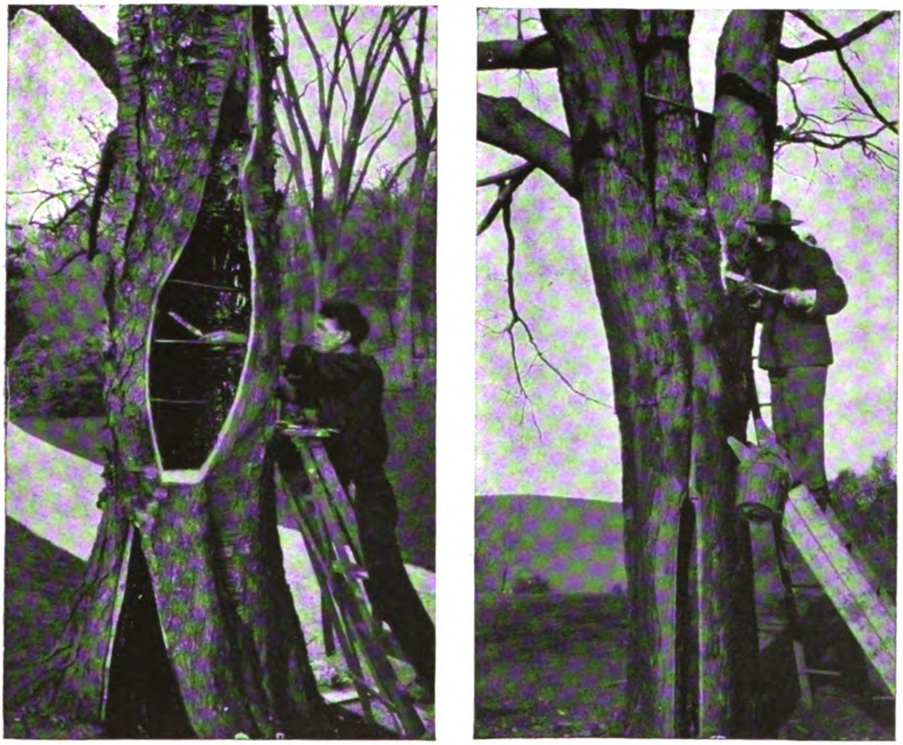
[*] *From a Paper by C. H. Easton, New York*

This is the reason why hollow trees may often be found in a flourishing condition when the heartwood may have entirely disappeared. However, a landscape tree in this condition, deprived of the shelter of its fellows, is in grave danger, for a high wind or a heavy snowfall may find it an easy victim.

After the mass of decay has been removed from the interior of the rotting trunk there remains a shell of living sapwood and bark. Into this cavity a steel brace is inserted and bolted in place. This gives to the tree a stability which by the decay of the supporting heartwood it had lost. Now comes an important operation, the cutting of the watersheds, which prevent the entrance of moisture. The watersheds consist of a deep groove cut about an inch inside the edeg and opening out to the ground below. The cement, being packed tightly into these grooves, forms a channel down which the water flows, to be led out at the base. The cavity is then wired throughout, the wire being stretched from nails driven into the wood, and acting as reinforcing for the cement. This work having been completed, the cement is made as moist as possible, and then built out into the original outline of the tree. The bark which has been cut back for an inch or so in order to prevent bruising while the work is in progress will eventually cover the filled in wound, the tree thus regaining its normal appearance.

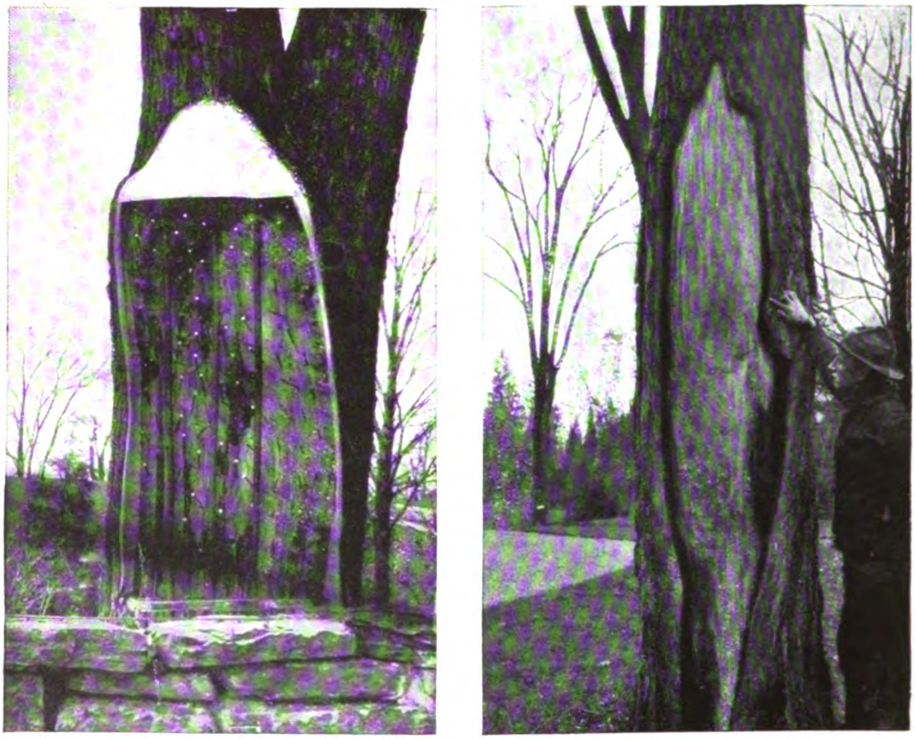


MAINTENANCE OF TREES.

A CAVITY REINFORCED WITH RODS. A CAVITY FILLED WITH CEMENT.

In the case of exceptionally large cavities the opening is covered by large strips of zinc. The cement is then forced down into every crevice and allowed to set, after which the zinc is removed and a coat of fine finishing cement put on and painted the colour of the bark. By this method the tree surgeon is enabled to build out trees where fully half the wood may have been destroyed by lightning or from some other cause. This treatment serves as a fine example of the healing powers of nature, for it is remarkable how quickly these wounds will heal when protected from moisture and further decay by the cement filling insured by the watersheds.

The correction of the forked or defective crotch which we find to a great extent in our soft maples and elms, and to a less degree in almost all our landscape trees, forms a large part of the tree surgeon's work. This form of crotch usually has its origin in the destruction of the original head or leader. In a case of this kind a double head is formed by the forcing out of two lateral buds. As these shoot up, forming the new top, the old stump at their base gradually decays, allowing water to penetrate into the crotch. Nature tries desperately to heal this wound, but the imperfect joint is constantly forced open by the wind and prevented from uniting by the old stump, until finally, weakened by decay, the tree splits. Many of our finest trees are ruined every year by the splitting of these defective crotches.


MAINTENANCE OF TREES.
A CAVITY REINFORCED WITH NAILS. PACKING A CRACKED CROTCH.

These cases are often exceedingly difficult to treat. The decayed matter must first be removed with great care and thoroughness—in fact, the dentist is not more conscientious in removing decay from a tooth than is the tree surgeon in cleaning out these cavities. The opening is then packed tightly with cement. Cutting watersheds in these crotches often takes all the workman's ingenuity and patience, for, working in the narrow limits of the fork, as he is compelled to do, it is exceedingly difficult to use his tools. But here most of all a perfect watershed is required, as the water running down the limbs and trunk would otherwise find lodgment behind the filling. In the case of a large tree the additional precaution is taken of putting a bolt directly through the crotch, while a chain is placed some twelve or fifteen feet up.

We have to thank the *Cement Age* of New York for our illustrations.

NEW BOOKS

AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the past year.

The Analysis of Cement: A Handbook for Cement Works Chemists. By Frank B. Gatehouse.

Published by C. Griffin & Co., Ltd., London, 1908. Price 5/-.

Contents: Introduction.—Analysis of Raw Materials.—Calculation of Proportion of Raw Materials.—Analysis of Fuel, Lubricants, Water and Kiln Gases.—Cement Analysis.—Appendix.

The importance of an accurate analytical control of all materials and finished products in a Cement Works is so great that any work that facilitates such control should be welcomed by all who have the interests of the industry at heart. Mr. Gatehouse's book describes the methods of chemical analysis which are required in the analytical laboratories of cement works, or in laboratories in which cement is regularly examined. The treatment of the subject is concise, the amount of detail being in all cases sufficient to indicate to anyone having ordinary analytical experience the course to be followed. In successive chapters the author treats of the analysis of chalk or limestone, clays, slurry, fuel, lubricants, water, kiln gases, cement and plaster, etc. The methods recommended are all practical and accurate, and in the present state of knowledge of the constitution of cement give all the information that is required in the works routine. It is satisfactory to see that the various methods for the estimation of "free lime," once a favourite with cement analysts, are entirely omitted, and it is to be hoped that this test has now finally disappeared.

The methods for the analysis of cement are in general rather simpler than those in vogue amongst American chemists, and are, in the present writer's opinion, to be preferred to them. It is not obvious, however, why the direct ignition of calcium oxalate to oxide in a muffle in the estimation of lime, which gives trustworthy results in careful hands, should be rejected in favour of two indirect methods, both of which are open to objection.

The methods of calculation of results, and of proportioning limestone and clay in making slurry, are thoroughly explained. An extensive appendix contains details for the preparation of reagents and standard solutions, tables for use with the calcimeter, etc., and others for use in determining specific gravities and in making tensile tests, although physical testing is not otherwise dealt with. The chemical nomenclature is that in use in scientific work, except that the obsolete "sodium hydrate," etc., is used in place of "sodium hydroxide." It is needless to say that the metric system is employed throughout, laboratory practice being still far ahead of works practice in this respect.

The printing and general style of the book are excellent, the very poor cut of a Bamber calcimeter on p. 49 being the only defect. Author and publishers are to be congratulated on having made a useful addition to cement literature.

Concrete: Its Uses in Building from Foundation to Finish. By Thomas Potter.

London: B. T. Batsford. Price 7/6 net.

Contents: History of Concrete.—Aggregates. — Matrices. — The General Application of Concrete.—Concrete Foundations.—History of Monolithic Walls and Appliances for Building Monolithic Walls.—Monolithic Walls and Methods of Construction.—Concrete Building Blocks and Block-making Machines.—Slab Walls and Faced Concrete Walls.—History of Fire-resisting and Concrete Floors.—The Application of Concrete to Floors, Roofs and Paving.—Reinforced Concrete.—Forms and False Work.—Concrete as a Fire-resisting material.—The Conductivity of Concrete.—Cast Concrete. — Concrete Stairs. — Concrete for Landed Estates.—Concrete Arches, Vaulting, Domes, etc.—Staining Cement.—The Shrinkage of Concrete.—Suggested Specification for Concrete.—Tables and Memoranda.

This important work, of which the year 1908 sees a third edition, the earlier publications taking place in 1877 and 1891 respectively, has, through the earlier matter being entirely revised, and with the many additions thereto, been brought thoroughly up-to-date, and the author must be sincerely congratulated on the able manner in which he has accomplished the end he had in view. At the same time, we think it is a pity he did not, in dealing with this work of 23 chapters regarding such subjects as suitable aggregates and experiments connected therewith, the character of various matrices, methods of constructing walls, floors, roofs, etc., criticise more fully the many patented fire-resisting floors which he mentions. We know, of course, that to do this with the many patented forms of construction would have absorbed a very great deal of time, but we think he should have stated his opinion with regard to those particular floors he mentions, for the mere mention of a fire-resisting floor without drawing attention to its weak points or otherwise is of no real use. We believe, had he done so, it would have been well received, not only by the patentees, but by architects and engineers generally. Speaking of the work as a whole, it contains much instructive and interesting information, more especially that part of it which treats of reinforced concrete, for the author, having had considerable practical experience, is able to place his facts in a manner invaluable to the student on this subject. We would particularly draw attention to the chapter regarding the history of concrete and fire-resisting construction from early days to the present time, but we regret the author did not give us the source from which he obtained his facts, which would, we think, have added considerably to the interest.

Beton Kalender, 1909.

Published by W. Ernst & Sohn, Berlin. Price 4s.

The enormous importance which reinforced concrete construction has assumed in Continental building and engineering practice is strikingly brought home to the reader who glances through the fourth annual issue of this well-known pocket-book. Taking Part II. first, we find nearly 500 closely-printed pages descriptive of recent advances and experiences in this mode of construction. The sections on foundations, on floors, and on pipes, sewers, canals, etc., are especially interesting, and are fully illustrated. The great variety of proprietary systems before the public is particularly conspicuous in the case of floors, but in general construction the tendency, at least in Germany, is towards a greater freedom of design than is compatible with the use of any single system. The manifold uses of reinforced concrete in ordinary buildings, in railway and municipal engineering, and in the construction of reservoirs, dams and docks are shown by the description of numerous works carried out recently, and described at length in *Beton und Eisen*, from which most of the descriptions are summarised. A section which will be of interest to many is that dealing with the construction of roads, in which numerous attempts at improving on the ordinary asphalt or macadam are described, most of which, however, appear to be still in the experimental stage.

Part I. takes the form of an engineer's pocket-book, and contains a great variety of tables, formulæ, and graphical methods of computation required by the reinforced concrete engineer, together with statements of legal and official regulations affecting the industry, the latter being, of course, mainly of German interest. Whilst the conservatism of English engineers in retaining the old weights and measures makes the direct use of Continental tables impossible, much practical information of a useful kind will nevertheless be found in this volume.

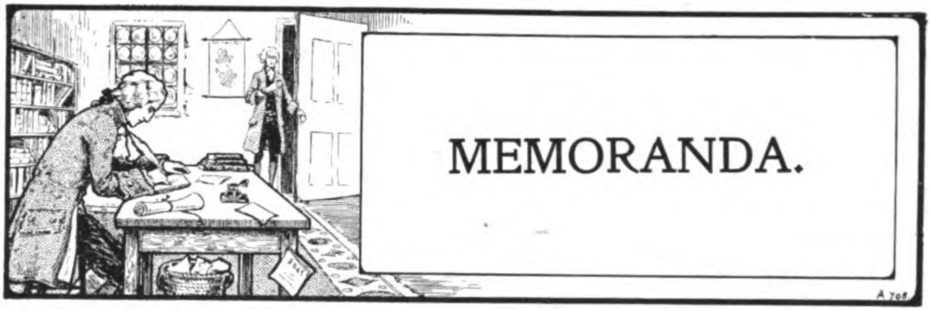
Cement Laboratory Manual. By L. A. Waterbury, *Professor of Civil Engineering, University of Arizona.*

Published by John Wiley & Sons, New York; Chapman & Hall, Ltd., London, 1908. Price 4s. 6d. net.

Contents:—General Instructions.—Description of Apparatus.—Laboratory Problems.—Three Appendices.

This little book consists of laboratory notes issued to students undergoing a course of instruction in cement testing, and is not adapted to technical use. The methods indicated are all familiar, and are very briefly described. Surely the application of the method of least squares to the averaging of tensile tests (p. 70) is a rather superfluous refinement, considering the comparatively rough nature of such tests!

Three appendices (pp. 93-122) contain the report of the Committee on Uniform Tests of Cement of the American Society of Civil Engineers, the Standard Specification of the American Society for Testing Materials, and the method of Cement Analysis drawn up by the New York Section of the Society of Chemical Industry. These appendices form, for those engaged in testing cement, the most valuable part of the book.



MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Fritz von Emperger (Vienna).—We observe with much pleasure that the Editor of our contemporary, *Beton u. Eisen,* who is resident in Vienna, has been accorded the honorary title of "Imperial Councillor-General for Construction," which is the highest technical titular distinction that can be conferred in Austria.

Proposed New Regulations in Manchester.—Among the items on the agenda for a special meeting of the Manchester City Council at the end of last year was the inclusion in the proposed Parliamentary Bill of a clause "to authorise the making of further provision as to the erection within the city of buildings in reinforced concrete, or with steel frame construction." If this clause receives the sanction of Parliament it will allow builders to secure the requisite strength in walls thinner than those they now make of brick, but, on the other hand, the proposed clause may mean restrictions where there is at present entire liberty of action. We deal with a similar question of giving facilities on the one hand but creating restrictions on the other in another part of this issue, where we refer to the proposed amendment of the London Buildings Act.

"The Times" and Fire Prevention.—We observe with much interest that an article in the Engineering Supplement of the *Times* dealing with the progress of fire prevention in the British Empire points to the notable effect the modern policy of advocating fire preventive measures has had on the introduction and development of reinforced concrete in this country. There can be no doubt that this is the case, although it is not generally recognised, and the reinforced concrete industry, if anything, resent the firm attitude which many authorities have taken up in demanding that reinforced concrete if used in certain classes of building shall have those attributes which tend towards fire prevention—*i.e.*, suitable aggregates and a proper protection to all steel work. If these attributes are not forthcoming much of the *raison d'être* of reinforced concrete would be lost—as far as buildings are concerned.

Reinforced Concrete Railway Sleepers.—We learn from a correspondent in St. Pölten (Austria) that some important tests were undertaken recently with reinforced concrete railway sleepers, which are intended to replace wooden sleepers. The tests took place in the presence of the principal officials of the Austrian State Railways, and very satisfactory results were obtained. Hundreds of trains ran over the portion of the main line where the new sleepers were fixed for some months previous to the tests taking place, and the results seem to promise well for the future of the reinforced concrete sleepers.

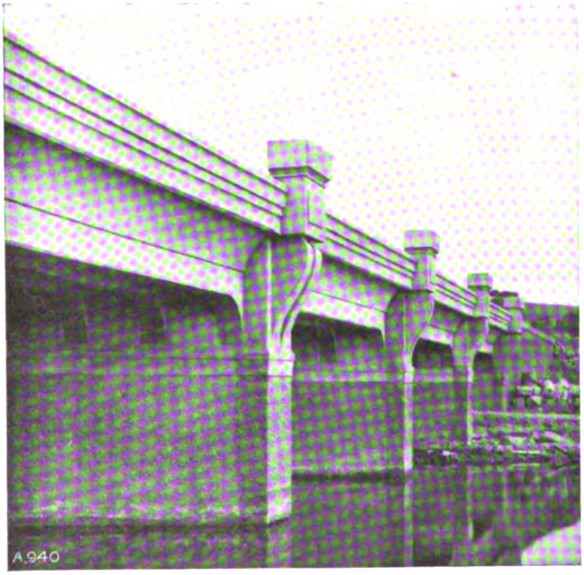
Owing to the increasing price of the wooden railway sleepers obtained largely from Russia, the management of the Prussian State Railways has decided to make an exhaustive series of tests as to the suitability of reinforced concrete sleepers.

A New System of Making Cement Pipes.—We understand that a new system of making cement pipes has been introduced in Germany by Messrs. Rentsch, Otton and Schlosser, of Meissen, Saxony, in which the cement used has generally an admixture of asbestos, and sometimes a reinforcement of expanded metal. A contemporary writes that the manner of consolidating the cement, whether with or without admixture of asbestos, is based on the action of centrifugal force. The pipes are generally made in moulds and are of a semi-liquid cement grout with an admixture of thin asbestos fibre. The moulds are placed in a machine, which gives them a speed of rotation varying from 300 to 1,500 turns per minute, according to their internal diameter.

Reinforced Concrete Water-Pipes.—A contract has just been awarded to the Columbian Fire-Proofing Company, Limited, 87 Union Street, Glasgow, for 9½ miles of reinforced concrete water-pipes on the "Bonna" system, for the Clydebank and District Water Trust's new scheme. The greatest head to be provided for is 280 ft. We understand that the reinforced concrete pipes showed a saving of £550 per mile over the corresponding price for cast-iron pipes. We understand that the contract price for supplying and laying the pipes is £18,000, and that Mr. Stuart is the engineer to the scheme.

Reinforced Concrete for Drains.—At a meeting of the Institute of Sanitary Engineers, held since our previous issue, Mr. J. Lawrence suggested the use of reinforced concrete with a view to replacing the stoneware drain. This form of construction had been applied in numberless other cases, and he considered it most suitable for drains. He suggested the embedding of wrought-steel rods or bars or lathing near the upper and lower surfaces of the concrete. The comparatively small amount of reinforcement necessary to a drain pipe would be met by the use of steel rods of very small section, and therefore at very low cost.

Strengthening of Corroded Tramway Poles with Reinforced Concrete.—A recent issue of the *Electric Railway Journal* contains an account of a method adopted by a tramway company in America for strengthening corroded tubular tramway poles by filling them with reinforced concrete. The cap at the top of the pole is first removed, and a suitable cage of twisted steel bars is dropped in. The lower ends of these rods are set firmly in a suitable base, but at the top a hooked cap temporarily confines the upper ends of the rods to allow the cage to pass through the narrower upper section of the pole. Upon the withdrawal of this cap from above the rods flare out towards the sides of the pole. A grouting is then forced in through a hose inserted at the top of the pole, from a tank in connection with a portable motor-driven air compressor, taking current from the trolley wire. These operations have been carried out in the case of a large number of poles by the New York Pole Company, who originated the system.

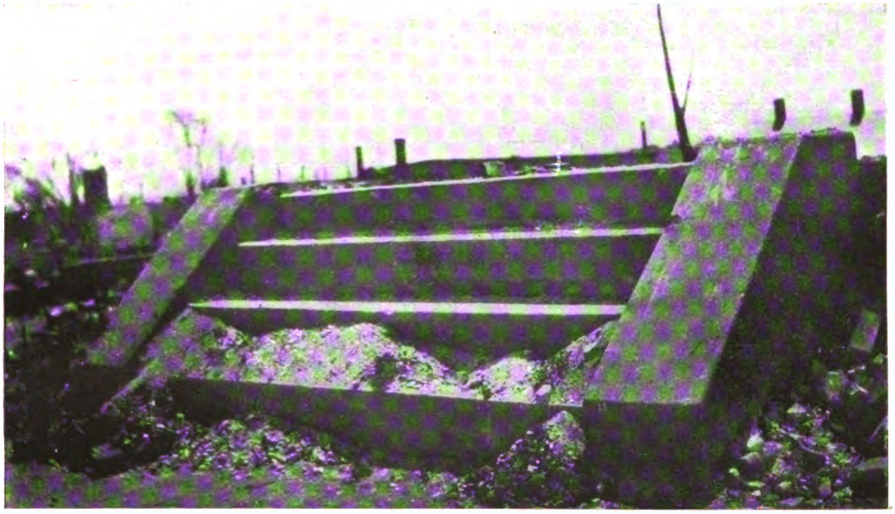


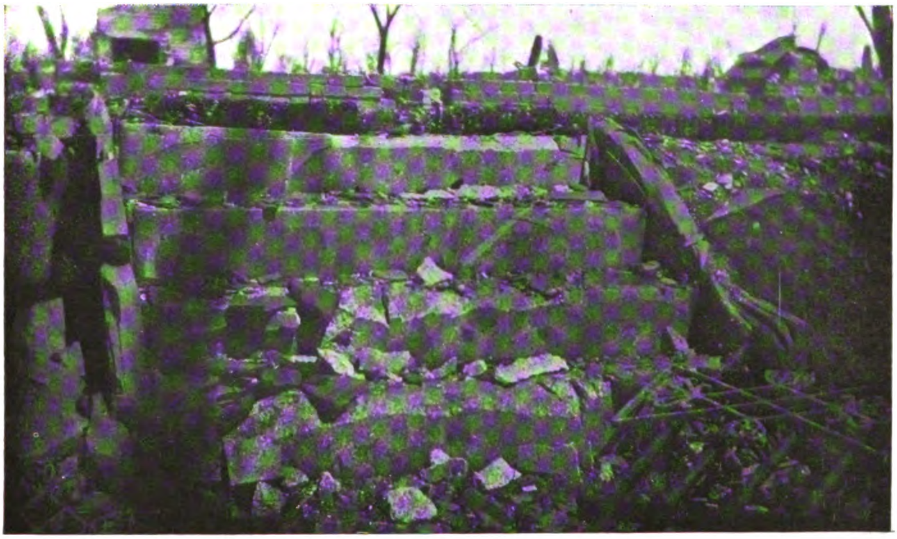
REINFORCED CONCRETE BRIDGE OVER THE HINDMARSH RIVER SOUTH AUSTRALIA.

Constructed by the Reinforced Concrete and Monier Pipe Co., Ltd., Melbourne.

Reinforced Concrete Bridge in South Australia.—Sir John Cockburn, referring to the uses of concrete in Australia, when speaking at a meeting of the Concrete Institute, mentioned the introduction of reinforced concrete in the Australian Commonwealth. The bridge illustrated on this page is an excellent example of the class of work being done.

Extension to the General Post Office, Dublin.—We understand that an extension consisting of a block 56 ft. in length is in course of construction. The new building, which is four storeys high, will have a depth of 120 ft. The basement at rear will be used for workshops, two large rooms on ground floor for a sorting office and postmen's room, and the other floors for various offices. The floors are to be carried on steel stanchions, and the roof will be of reinforced concrete (expanded metal being used as the reinforcement), covered with Limmer asphalte. The architect for the work is Mr. Robert Cochrane, I.S.O., LL.D., of the Board of Works, and the specifications have been prepared by Messrs. Patterson and Kempster. The estimated cost is close on £20,000.





Jamaica Conflagration.—We have received two photographs, taken at the Jamaica fire, which are certainly of sufficient interest for publication even at this late date, having regard to the fact that they show so clearly the difference in the power of fire-

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resistance of natural stone as against concrete. In this case a flight of steps in open ground are shown. The difference in fire resistance certainly claims comment. We are indebted to our contemporary, *The Cement Age*, of New York, for the photographs.

Bombay Harbour Improvements.—The following is an extract from a contemporary regarding the making and placing of the concrete blocks used in the construction of the new breakwater at Bombay. The particulars show how work of this kind has occasionally to be carried out under very difficult conditions:—

The construction of the new breakwater at Bombay is one of the most notable achievements in the history of submarine engineering in India. First of all powerful dredgers were employed to create a channel along the route the breakwater was to take, reaching down to the hard rock that forms the real bed of this portion of the Indian Ocean. This rock was found at depths varying from 33 to 43 ft., and was laid entirely bare from the shore to a distance of over a quarter of a mile out to sea. The next step was to level the rock in order to get a smooth surface upon which to place the huge blocks of concrete of which the breakwater is composed. This work was carried out entirely by Chinese divers especially trained for the work at Hong Kong, and who proved highly efficient and skilful workmen, remaining under water for very considerable periods at a time and carrying out their work with considerable intelligence. In order to assist this levelling and to make the submarine work as light as possible, blasting of protruding rocks was resorted to on a very extensive scale, it being estimated that between 7,000 and 8,000 cu. ft. of rock were thus removed. As the Chinese divers progressed with their levelling and provided an even surface of hard cement to serve as a foundation for the concrete blocks, preparations for placing these in position were rapidly pushed forward, and the manufacture of the blocks was taken vigorously in hand. The Portland cement used was all exported from this country, and it may be added that in place of the barrels usually employed for shipping this cement abroad the experiment of utilising old jute bags was tried with complete success. Not only were the bags more convenient to handle, but the cement arrived in India in much better condition than is usually the case when barrels are used.

Special machinery for the manufacture of these blocks was designed by the Chief Engineer of the Bombay Port Trust, and this was very successful. Several sizes of blocks were made, the largest weighing over 20 tons. The blocks were very rapidly manufactured, as many as 36 being completed in one working day, representing a total output of over 250 cu. yds. of concrete. In all the breakwater required something like 75,000 cu. yds. of concrete blocks. To place these blocks in position two heavy cranes, weighing over 170 tons each and with a working radius of 70 yds., were erected, and were gradually moved forward along the top of the breakwater as the work progressed. Two highly-trained British divers with considerable experience in work of this description worked in conjunction with the cranes, guiding the blocks carefully into position as the cranes dropped them below the surface. When the blocks were properly laid they were dowelled together on every side by means of bags of pure cement placed in the grooves left in each side of the blocks. Thus the whole structure was bound firmly together into one conglomerate whole.

The breakwater was built in sections of 35 ft. at a time. The divers worked in energetic fashion, as many as 54 blocks being placed in position in one day. Each man worked under water for about five hours, when he was relieved by his companion. The top of the breakwater is composed of smaller blocks, bound firmly together by liquid cement poured into the interstices. Over all was placed a 2-ft. layer of cement, the top being made slightly convex for drainage purposes. A feature of the breakwater is that it does not actually reach to the shore, a passage being left over which a concrete bridge that is the largest and heaviest of its kind yet erected in India has been carried. This opening has been left in the hope that the action of the sea will prevent some of the silting in the basin that might otherwise have taken place. A curious feature of the top of the breakwater is the bollards or mooring posts for the use of the ships lying alongside. There are about twenty-five of these in all, and each is in reality an old cannon, of which there is a large quantity scattered about the dockyard. Some of these guns, it may be added, were used by Wellington's army in India, while others were forged as recently as 1890.

GENERAL.

The "Taylor" Mixer.—Messrs. Henry Balfour & Co., Ltd., of Leven, Fife, have sent us a very excellent booklet on their Taylor concrete mixer. With the mixer itself we are dealing in this issue in the article specially devoted to the subject (*see* p. 468).

We would, however, call attention to the booklet, inasmuch as it contains some very useful hints as to the application of the appliance, and also some particularly good illustrations of instances where the machinery has been installed. From the booklet it may be seen that the mixer was used in connection with the Admiralty works at Simonstown and Hong Kong, on the dock works at Methil and Burntisland, and on the extension works at Keyham, Devonport, as also on the Tynemouth Corporation Waterworks, and in many other notable instances.

The reports given by some of the engineers as to the amount of mixing turned out are certainly very interesting; for instance, 1,250,000 cu. yds. were mixed by these machines at Keyham, with a maximum output of 318 cu. yds. in 10½ hours. 300,000 cu. yds. were mixed at Hong Kong.

D. G. Somerville & Co.—We are advised that this firm are building new offices for their Engineering staff at Archangel Wharf, and have transferred their London office to 116 Victoria Street, S.W.

Patent Indented Steel Bar Co., Ltd., have sent us the December number of the Indented Bar Bulletin, which contains a description of the new Pavilion at Rhyl, in which their bars were used.

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